

→ ~~from~~ depth

front surface

25 mm?

A tooth

Pseudodontomys
beak retruded

32

B

28

C

Present
Grade

43 mm

outer lines give limits of slab of rock

Osteodonta ori

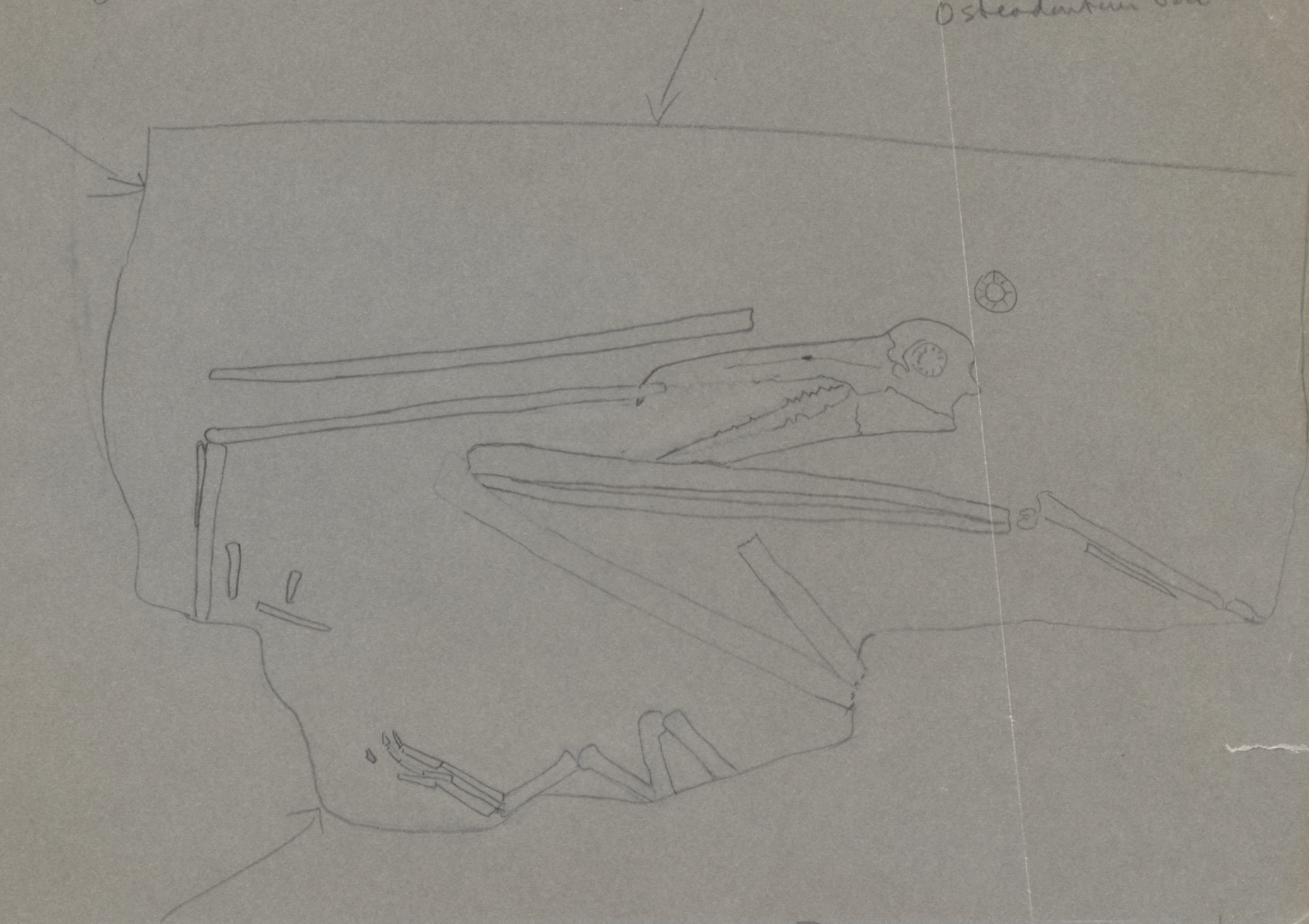


Fig. 3 This is traced from
a. H. - 10. 11. 12. to give
maximum detail

Tepic, Sonora, Mexico
Santa Maria Fossil

inches

mm

Pelican (or)

length ulna	25.5 inches	646.7 mm.	48%	310.66
length carpus	10.0 "	253.6 mm	49%	124.8
length wing phal.		114.1 mm	40%	45.6
length wing phal.		78.6 mm		33.3
" short wing "		49.0 mm.	68	33.3
" tarsus	4.5	114.1 mm.	68	77.7
br. cuneiform		21.2 + 17.4	77	16.4 + 10.1
depth "		21.0 + 14.3		16.0 + 12.7
Ratio carpus ulna		39%		40%
Ratio tarsus to 1st ped. phal.	61			
Ratio tarsus to carpus	44			60
Ratio cuneiform length carpus	108.3%			12
Ratio tarsus ulna	17%			21%
Length beak from orbit	3.5			
Ratio beak to ulna	48%			

19.5 inches *D. nigripes* feathers from wrist joint & tip
 humerus + ulna each $10\frac{1}{2} = 21 + 19.5 = 39\frac{1}{2} + \text{body } 3\frac{1}{2} = 43''$

15.75" humerus *D. exulans*, $15\frac{1}{2}''$ ulna (same) 5.75" body? (arm from $\frac{1}{10}''$)

$$\frac{31\frac{1}{2}}{31\frac{1}{2}} = \frac{3}{3} = 68\frac{1}{4} = 5'8\frac{1}{4}'' + 2 = 7'5\frac{1}{4}''$$

wing length of *Fregata* 23-27 inches

ulna $9\frac{3}{4}$, humerus $7\frac{1}{2}$, carpus $4\frac{1}{2}$, 3 inches body 20" (minus feathers)

$\frac{5}{8}''$ carpal

$$\frac{178}{54} = 7'11\frac{1}{2}'' \text{ spread}$$

Brandt + Common

humerus $6\frac{1}{2}$, ulna $6\frac{1}{4}$, $2\frac{1}{2}$ body

Fregata aquila

D. nigripes

D. exulans

humerus 7.5

10.5

15.75

ulna 9.75

10.5

15.5

humerus 7.5

10.5

15.75

ulna 9.75

10.5

15.5

* wrist 25

19.5

24

* wrist 25

19.5

24

body 3

3.5

57.75

87.50

84.5

$$12 \overline{) 1625} (9'8\frac{1}{4}'')$$

* wing from wrist to tip of feathers

Fossil

humerus 25

101 39 $\frac{1}{2}$

101 126 $\frac{1}{2}$

ulna 25 $\frac{1}{2}$

79

227

humerus 25

180

875

ulna 25 $\frac{1}{2}$

9 $\frac{1}{2}$

23575

$$12 \overline{) 189\frac{1}{2}} (15'9\frac{1}{2}'')$$

$$12 \overline{) 23575} (19'7\frac{3}{4}'')$$

albatross

101.0

figate proportion

76

moorhen

77.5 wings (feathers)

140

75010

9.5 body width

8.75

6825

$$12 \overline{) 1880} (15'8'')$$

$$12 \overline{) 249.75} (20'9\frac{3}{4}'')$$

6750

$$\begin{array}{r}
 .46 \\
 9475 \overline{) 450.0} \\
 \underline{3900} \\
 6000 \\
 \underline{5850} \\
 1500
 \end{array}$$

$$\begin{array}{r}
 1076 \\
 975 \overline{) 75.00} \\
 \underline{6825} \\
 6750
 \end{array}$$

D. nigripes skin
 hum. tube 21
 feathers from 19.5
 with tip 40.5
 81.0
 body 7.0
 12) 88.0
 7' 8"

Fregata R
 ulna 9.75
 H. 7.5
 feathers 24.0
 with tip 41.25
 41.25
 body 3.80
 12) 86.00
 7' 4"

commonant?

6.25
 6.50

12
 24.75
 24.75
 5
 12) 54.50
 4' 6 1/2"

if humerus as in albatrus or commonant
 hum. 25 1/2 25 1/2
 ulna 25 1/2 25 1/2
 50.9 50.9
 est. body 51
 102
 8
 111
 92.8 feathered wing
 12) 203.8 (16' 11 3/10")
 12
 83
 72
 11 8

if humerus as in *Fregata* to my report.
 19.25 19.25
 25 25.0
 44.25 44.25
 44.25
 88.5
 feathers 52
 52
 19.25
 body 8.3
 12) 200.8 (16' 8")
 12
 80
 72
 88

27
 97.5) 75.00
 65.15
 30.85
 casp. hornat
 25 25
 25 25 1/2
 50 1/2 50 1/2
 50 1/2
 101
 9
 101
 211

length wing

650 ulna
 252 casp. hornat
 70 phalange
 670 humerus (per albatrus)

650
 252
 70
 542 humerus per albatrus

39370
 3922
 68740
 68740
 354330
 118110
 12) 54299 140 (12' 10 1/4")
 12
 34
 134
 102
 13' 7 3/4"

1642
 319 primary feather
 1961
 1961
 3922

1514
 1319
 1533
 1833
 3666

Comparative measurements

	Pseudodactylus	(Tepuquet) P. ori	Odentopterus
Depth articular at quadrato articularis	28? 14.0 x 2	27.6 18	9 mm - 17.
Depth art. below ant. border, orbit	37 20.0 x 2	39	
Dist. orbit to nares	110 mm	110	35.9
Dist. anterior nares	90	91	24 ap.
Pr. cran at temp. fossa			45
Length, exoc. to post. orbit	44	240	16
Length furcal			50
Pr. Interorbital		24.5'	12
Pr. fronto nasal suture	26 $\frac{1}{2}$?	28?	20
Ant. post diam. orbit	72.6	57.0	30
Vert. diam orbit	48 25.5 x 2	47.7	27
Length zygoma	100 54 x 2	84.5	48.5' ^{meas on} illu
Pr. zygoma	17.5' (1790)	10 (190)	4.5'
HF distance at nares ant	34.5' ^{post} 36	38 ⁴⁰	16.5' ? narrower
Depth mandible at corner	53	53	
Cranium post. orbit	47	36	20.5'
Length cran. post skull from fronto nasal suture	141	102?	62.4
Dist mand. suture to art. with quadrato	121 64.5	91.3	45.5'?
Suture to post edge mand.	122 (short) 69.2	119 (longer suture)	
Depth mandible 15 mm ant to post edge nares	25	28.2	

	<u>Diomedea albatrus</u>	<u>900 fossil</u>	<u>Larus aquila</u>
Length ulna	266.28	41.20	38
Length carpus	100.2	39.5	45.5
Length wing phas	50.0	43	44.2
" ch. " "	21.4	43 (51.8)	58 (70.8)
" tarsus	89.0	78	18
1st metacarpal, or cuneiform	10.6 + 6.3	50% T 36	66.9 + 67
depth cuneiform	10.3 T 7.4	49% T 57	76 T 79
Ratio carpus to ulna	38.20	39.20	46.20
Ratio tarsus to carpus	88	44.20	18
Ratio tarsus to 1st metacarpal			
Ratio cuneiform to depth carpus	10.20	108.30	12.20
Ratio tarsus to ulna	34.20	17.20	8.20
Length beak from eye socket	118.5		113.?
Ratio beak to ulna	44	48	40.20

$$4 \frac{12}{16} \div 1 \frac{3}{16}$$

$$\frac{64}{76} \div \frac{19}{16}$$

$$\begin{array}{r} 4 \\ 19 \overline{) 76} \\ 76 \end{array}$$



$$\begin{array}{r} 34 \quad 5'2 \\ 16 \\ 2 \\ 19 \overline{) 52} \\ 38 \\ \hline 140 \end{array}$$

300

$$\begin{array}{r} 150 \\ 150 \\ 107.8 \\ \hline 407.8 \end{array} \quad 11 \frac{3}{4}$$

$$9.37 \overline{) 74.120} = \text{fifty}$$

$$\begin{array}{r} 74.120 \\ 9.37 \overline{) 74.120} \\ 6859 \\ \hline 3910 \\ 3748 \\ \hline 1620 \end{array}$$

160 inches

$$\begin{array}{r} 150 \\ 6.3 \\ 8 \end{array}$$

$$\begin{array}{r} 8.2 \\ 5.78 \\ 8 \end{array}$$

$$\begin{array}{r} 74.1 \\ 25 \\ \hline 3705 \\ 1482 \\ \hline 18523 \end{array}$$

$$\begin{array}{r} 138.8 \\ 65.7 \\ 71.0 \\ \hline 275.5 \end{array}$$

Albatross (L. ulmaria) ratio tarsus to ulna = 29%
 Fossil " " " " = 8%
 Fossil " " " " = 18%

Albatross (L. ulmaria) ratio carpus to ulna = 35%
 Fossil " " " " = 46%
 Fossil " " " " = 40%

Albatross ratio ulna to wing spread = 26%
 Fossil " 2 ulna " " = 21%

Fossil wing spread at ulnas = 21% $245'' = 20' 5''$
 Fossil " " " " = 26% $196'' = 16'$

Fossil " " based on proportion of humerus + ulna to length of wing in albatross $188\frac{1}{2}'' = 15' 8\frac{1}{2}''$

Fossil wing spread based on proportion of humerus + ulna to length of wing in Fossil birds $249.75'' = 20' 9\frac{3}{4}''$

Fossil wing spread based on proportion of ulna to length of wing in albatross $189\frac{1}{2}'' = 15' 9\frac{1}{2}''$

Fossil wing spread based on proportion of ulna to length of wing in Fossil birds $235\frac{3}{4}'' = 19' 7\frac{3}{4}''$

Fossil wing spread based on proportion of ulna to length of wing in Pelecanus $174.85'' = 14' 6\frac{2}{3}''$

Fossil wing spread based on what is known of bones of wing + feathers - Body to be estimated (8" + 7") $163'' = 13' 8''$



$$\begin{array}{r} 58 \\ 13 \\ \hline 12 \overline{) 716} \end{array}$$

Albatross - Primary #1 is longest (210) extent 10' wing 2' exulans (260 wing/extent) nigripes 19-20" wing

Pelecaniformes - 10 primaries "20" albatross fuliginosa

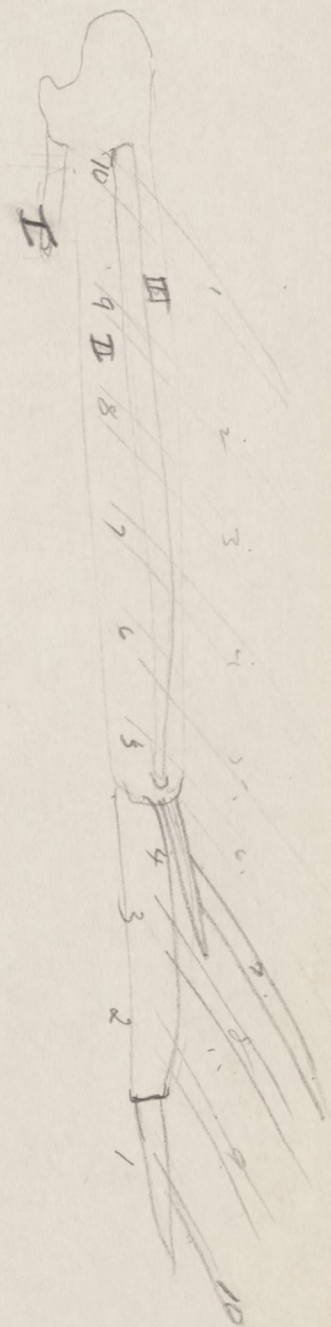
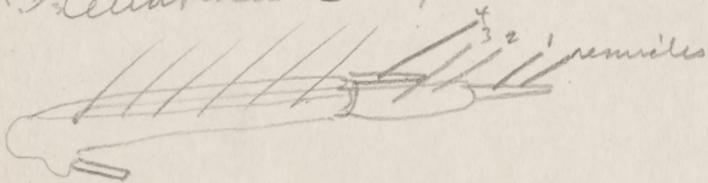
Boobies #1 longest

Pelican extent 8-9' wing 2' (white) 6 1/2' (21 brown) 2670 wing extent 18.5-

Condorant #2 & 3 longer than #1 #2 usually longest

Frigate #1 longest extent 84-96 in. wing 23-27 in.

Anatides - 10 primaries + 1 smaller



fossil carpus 252
Digit 2 70
322 mm = 12.7 inches

feather 13
13
25.7

fossil ulna 6.47
humerus 500+

1469 = 58" 13" feather

71' = 6'

body breadth 9 1/2"

12) 151 1/2 (12' 7 1/2")

12
31
24
7 196850

D. exulans 24.0 wing

carpus 5.5
18.5 feathers

= 2.5' Digit 2 Ph 1
16.0 feather length?

236220
258660 90

254
19
2286
254
4826

252 21700
2016
1540
110 112

138 61530
13410
1420

39376
1388

314960
314960
118110
39370
54645560

647
252
70.1

19.
25
95
38
475

74.5
647 | 482.0
4529
2910
2588
322.0
3235

647 - 650
252
70.

482
1451

1451
39370
101570

5353
13059
4353

57,215870
16.5

73.7

73.7

147.4

9.5

12) 1569 (13'9"
12
36
36

656
103
1950
6566
68950
4

39370
803
119110
314940
31,61511.0

57,21587
3,16151
60,37735

3

6570
252
70
469
1641

1641
39370

114870

4923

14769

4923

446,0.6150

165

1811

1811

4622

10

12) 4632 (13.6"
12
43
38
72

650

650

252

70

1622

39370

113540

4866

14598

4866

63858140

64,60.6170

16.5

81.1

81.1

162.2

9.5

171.7 (14.37'
10

12

51

48

3

13
12
26
13
156
143

14
12
48
12
168

255.8
228
983.3

250
232
482

Calculation giving extent

Ulna 649. mm

carpus 252

ung. phal. 70

humerus 593 +

longest feather 404

$$\begin{array}{r} 1968 \\ 1968 \\ \hline 3936 \text{ mm.} \end{array}$$

$$\begin{array}{r} 393.6 \\ .39370 \\ \hline 275520 \\ 11808 \\ 35424 \\ 11808 \\ \hline 12 \overline{) 154.960320} \quad (12' 10.96'' \\ 12 \\ \hline 34 \\ 24 \\ \hline 109 \\ 108 \\ \hline 16 \end{array}$$

$$\begin{array}{r} 12' 11'' \\ 9 \text{ bones, br?} \\ \hline 12' 20'' \\ 13' 8'' \end{array}$$

$$\begin{array}{r} 649 \\ 252 \\ 70 \\ 80 \\ 593 \\ \hline 1644 \\ 39370 \\ \hline 115080 \\ 4932 \\ \hline 14796 \end{array}$$

$$\begin{array}{r} 39370 \\ - 404 \\ \hline 157480 \end{array}$$

$$\begin{array}{r} 157480 \\ 137480 \\ \hline 12 \overline{) 15.9050000} \quad (15' \\ 12 \\ \hline 3 \end{array}$$

$$\begin{array}{r} 298 \\ 280 \\ \hline 378 \end{array}$$

620

$$\begin{array}{r} 593 \\ 77 \\ \hline \end{array}$$

$$\begin{array}{r} 39370 \\ 77 \\ \hline \end{array}$$

$$\begin{array}{r} 275590 \\ 275590 \\ \hline \end{array}$$

$$\begin{array}{r} 275590 \\ 3,03149 \end{array}$$

$$\begin{array}{r} 3,03149 \end{array}$$

$$\begin{array}{r} 14796 \\ 4932 \\ \hline 12 \overline{) 174.85} \end{array}$$

$$\begin{array}{r} 14' 6 \frac{2}{3}'' \end{array}$$

$$12' 11''$$

$$12 \overline{) 163.96}$$

$$\begin{array}{r} 12 \\ 43 \\ 36 \\ \hline 8 \quad 96'' \end{array}$$

Relian

$$\begin{array}{r} 39370 \\ 357 \\ \hline \end{array}$$

$$\begin{array}{r} 12 \\ 54 \\ 48 \\ \hline 6 \end{array}$$

$$\begin{array}{r} 9.00 \\ - 96 \\ \hline 8.04 \end{array}$$

$$\begin{array}{r} 275590 \\ 196850 \\ 118110 \\ \hline 14,055'090 \\ 236220 \\ \hline 25551130 \end{array}$$

$$\begin{array}{r} 39370 \\ 649 \\ \hline \end{array}$$

$$\begin{array}{r} 354330 \\ 157480 \\ \hline \end{array}$$

$$\begin{array}{r} 25.5 \\ 96 \\ \hline 1530 \\ 2295 \\ \hline 2448.0 \end{array}$$

$$\begin{array}{r} 174.85 \\ 2448.0 \\ \hline 14 \overline{) 2448.0} \\ 14 \\ \hline 104 \\ 98 \\ \hline 68 \\ 560 \\ \hline 1120 \end{array}$$

$$14 : 96'' = 25 \frac{1}{2}'' X$$

$$14X = 174.85$$

$$\begin{array}{r}
 1965 \\
 \hline
 39370 \\
 137550 \\
 5895 \\
 17685 \\
 5895 \\
 \hline
 12 \overline{) 77.352050(6\frac{5}{10}} \\
 \underline{12} \\
 5
 \end{array}$$

$$\begin{array}{r}
 1943 \\
 \hline
 39370 \\
 136010 \\
 5829 \\
 17487 \\
 5829 \\
 \hline
 12 \overline{) 764959 + 0(6} \\
 \underline{72} \\
 4 \\
 6'5 \\
 6'5 \\
 \hline
 12'10 \\
 7 \\
 13'5
 \end{array}$$

12 $\frac{5}{8}$ inches sclerotic ring to tip of upper jaw

4 $\frac{1}{2}$ " " " to nares "

14 mm length of 'ext. nares'

30 mm. fit upper mandible at contact with skull

wing 25 $\frac{1}{2}$

" 25 $\frac{1}{4}$

other one - 25 - 25 $\frac{1}{4}$

10 " *Calymene*

tarsus 4 $\frac{1}{2}$ "

26 $\frac{9}{10}$ mm. dept tarsus

70.3 mm. phal, pedal $\frac{45.6}{45.6}$ p. 2. ungual 15.2

wing phal 65.2, 41.4 shaded

ulna 25 $\frac{18.90}{4.50}$ tarsus
25
20.0

ulna 25 $\frac{48.90}{10.0}$ carpus
Tarsus & carpus
10 $\frac{.45}{4.50}$

albatrus tarsus to ulna
15.5 $\frac{4.50}{3.10}$ 2.9
0 $\frac{1.40}{1.395}$.50

ligate tarsus 8.90
19.3 (= 3 $\frac{3}{4}$ ") ulna 9 $\frac{3}{8}$ humerus 7 $\frac{1}{4}$ carpus 4 $\frac{1}{2}$

Albatrus beak 8 $\frac{1}{4}$ (eye to tip)

15 $\frac{3}{4}$ humerus

15 $\frac{1}{2}$ ulna

5.1 carpus - 33.90

4 $\frac{1}{2}$ tarsus

15.5 $\frac{35}{5.50}$
4.6 $\frac{3.0}{8.75}$
carp to ulna 7.75

9.5 $\frac{.16}{.75}$
3.00
2.20

9.37 $\frac{.088}{.7500}$
7.498
90.40

ligate 2
9.37 $\frac{.048}{4.500}$ 90 carpus/ulna
3.748
7.520

zmmxn dmcn xmxm xncm vncm

$$\begin{array}{r} 7 \overline{) 192} \quad (27.4) \\ 14 \\ \underline{52} \\ 44 \\ \underline{30} \end{array}$$

16' wingspread = 192" narrowest part $\frac{1}{7} + = 27 \frac{1}{2}$ "

skull & beak = 16" = $\frac{1}{12}$ wingspread
beak is 12"

tarsus = $4 \frac{1}{4}$ "

toe 2 $5 \frac{1}{4}$ "

toe 3 $5 \frac{3}{4}$ "

toe 4 6"

$$\begin{array}{r} 12 \\ 16 \overline{) 192} \\ 16 \\ \underline{32} \end{array}$$

Skull $15 \frac{1}{2}$ inches - add $1 \frac{1}{8}$ " for horny beak & feathers = $16 \frac{5}{8}$ "

Beak $11 \frac{5}{8} + \frac{1}{8}$ for horn = $11 \frac{3}{4}$ "

$$\begin{array}{r} 4 \\ 11.52 \overline{) 4750} \\ 4828 \end{array}$$

568

844.1

$$\begin{array}{r} 11.52 \overline{) 2550.0} \\ 23 \\ \underline{1800} \end{array}$$

O. orri
620 humerus? longest feather 404
649 ulna
257 carpus
150 wing phals
1746
x 5
8780? extent
based on exulans

exulans
humerus 407
ulna 395
carpus 139
phals 136
1077 (= 20% of longest)
x 5
5385

Length cranial area from sclerotic ring to supraorb. 45.5
 Fossil 400 412 456

Length skull 404 mm 27 397 (12 1/2")
 Length beak 310 mm 300 317 (12 1/2")
 Length "to sclerotic ring 320 mm 319 (4.24.56)
 Length beak 300 to beak alone?

Tip beak to ant. edge 192 mm 191

Length nasal opening 16.5 15.5 16.5

Length from upper edge beak to post. edge of nares 90 mm. 93

Length diagonal sulcus from post. angle of nares 82.5 mm.

Length zygoma 84.8 mm.

Depth beak 59.5 to deepest part of palatal

" " 40.0 outer edge, at level of center of nares

" " 43.1 at post angle (not to palate)

" " 45.1 " " diagonally from hinge

Depth to start of sulcus 33.4

Dist. from dorsal hinge of rostrum diagonally to start of sulcus 34.5

Dist. from lower edge of nares lat center on sulcus to edge of rostrum 22.0 mm

" " " " " " " " " " dorsal edge " 18.0 mm.

Dist from dorsal edge beak to sulcus at post edge of tooth 17.3

" " " " " " " " " " to edge of beak at post edge of tooth 23.2

" " " " " " " " " " sulcus to edge of beak just past 1st tooth 5.8

Length zygoma 85.9 (83 x 13.7)

Length lower mandible from articular (post edge) to post part of symphysis 35.0 (36.7?)

Length " " " " " " " " " " " " " " " " 29.8

Depth " " " " " " " " " " " " " " " " 50

" " " " " " " " " " " " " " " " 56.2

" " " " " " " " " " " " " " " " 56.0

Dist center of suture to post. tip articular (along ventral border) 107.5 (110)

Depth lower mandible at anterior edge articular 26.9

Breadth orbit 53.3

Breadth sclerotic ring 42.5 x 42.5 Left 39.2 x 42.3 at

Breadth inner circle, sclerotic ring 29 x 31 " 26.2 x 26.2 "

Longest tooth - lower jaw

br. at base 9.9 mm. ht. 13.8

Another large tooth - base 7.9

large front tooth above br. at base 8.3, 13.0 ht

Next (possibly) largest br. at base 3.8; 7.6 ht

" " " " br. at base 5.5; 6.9 ht

br. at front
 nasal aperture
 27.00

dist. post. shell
 to ant. rim of
 orbit 90 mm.

br. frontal
 over eyes
 23.5 - 24.0?
 ht. 41.5 nostril
 at hinge
 rim of orbit to
 nares 104 mm
 suture to nares 94

45.5 from center
 50.0 of lower teeth
 47.0

In front of head + prox rad-dist humerus
into palatal area

Isid

Left scapula? 6.39.0

Below head + humerus
over of the slab

Right ulna

Length 64.7 (olecranon) 64.3. facet

Br. prox 32.0 (32.2 slab. 2)

Br. dist 13.5 (13.8 slab. 2)

Least Br. str. (20.2)

Right radius

Length 63.1 (? end not clear)

Br. dist. 16.5

Least Br. str. ^{mid} 15.3 (distals 13.4)

Right coraciform

Br. straight 20.6

Left ulna

652-650?

20.3

Left radius

64.3

16.0

12.9 (at prox. 9.5)

Br. prox end 14.6

Left coraciform

Dist. 20.2 + 14.5

Br. at tips 21.7

Rt carpometacarpus

Length

Br. dist

Left carpometacarpus

252.0

20.0

Rt. wing digit #1

Length 117.8

Left wing digit #1

117.8

Rt wing phal #1 digit 2

Length 70.1 Br. 17.4

Rt wing phal #2 digit 2

Length 80.3

Rt wing phal #1 digit 3

Length 42.9

Total length hand

carpus (252.0)

phal 1 digit 2 70.1

11 2 11 2 80.3

402.4

252.0

Right humerus

Length (patern) 205 (1/2)

Br. dist 34.2?

Dist. dist

Br. str. 20.2 (just below prox) 22.7 depth a little further distals

Length wing

Humerus (585?)

ulna 647

Hand 402

1634 = 5'4 3/8"

Left humerus

585? (est. 407 + 350)

51.8 (312) broadest part

17.9 dist. ly?

585

643
252
402
129.7
402 hum +
129.7

Left leg.

Leslie

Length tarsometatarsus 114.3

Depth prox 30.4

Depth dist 17.0 depth mid. trochlea only 11.0 mm? Beyond this notch for digit 2 protrudes from below

Depth shaft 17.8

Fourth Toe

15.0.4 { Phal. 1 length 63 mm? Depth dist. end 8.0
Phal 2 " 36.8 mm " " " 6.6 Depth prox 9.3 (7.1)
Phal 3 " 26.6 mm " " " 4.4 7.3 (5.8)
Phal 4 " 24.0 mm Round shaft. 2.1 4.3 (3.7)
Unequal 11.7 mm Depth (gr) 4.6

Third Toe

14.5.1 { Phal. 1 75.3 Depth Distal 8.4 " " 9.3 (6.2?)
Phal 2. 45.8 " " 8.6 " " 10.6
Phal 3 space for 24.0 32.5 bone atonesid
Unequal 15.0 Depth 4.4

Second Toe

13.4.5 { Phal 1 81.6 Depth Dist. 8.1 Depth prox 10.3 (9.8)
Phal. 2 53.9 " " 5.8 " " 10.2 (8.4)
unequal 16.4 Depth 4.9

Depth Dist end tibiotarsus, 23.7 int. condyle, 19.7 ext. condyle 32.6?

Length distal $\frac{1}{2}$ left tibiotarsus 111.1 (lying on its side - int side down on slab 1)

lying ant end down on slab, 1 { " prox $\frac{1}{2}$ " " 75.9 and 89.7 to main prox part
94.4 to ext. condyle end
139 int. condyle end

Femur - Depth ext. condyle? 24.1
Depth fibula " 19.0
Depth int. " ? 14.9
diag depth dist end 32.1

Tibiotarsus - breadth prox ant. surface 25.8

" Breadth prox dist. condyle 30.5
" Depth dist sh 15.0 (br. prox sh 16.2 above fibula ridge on " 23.7)

Depth shaft femur 21.3 (squashed)

Caudals - length 79.8, Br. tarsus process 38.7

length 3 broad caudals 22.2

Ratio tarsus to ulna 1720

	<i>D. nigripes</i>	<i>D. exulans</i>	<i>Pelecanus</i> cauty	<i>Tossie</i>	<i>Jepetra</i>
Ratio humerus to ulna	102%	103%	61%	111%	67.7
Ratio carponeta to ulna	36	35	39.7	38	47%
" length Digit 1 to carpo	45	44	35	46	52.4
" " " 2, Ph. 1 to "	47	47	38	52.7	44.9
" " " 3 " "	21.5	18.5	26	15	52.4
" " " 2 Ph 2 " "	49	51	37	31	43.1

Total length pedal Digit 2 -	89.8	116.2 mm	68.6	13.5	5
" " " 3	101.2	136.4	103.0	14.5	1
" " " 4	104.5	141.0	135.6	15.0	4
Ratio digit to length tarsus 2	100	99.0	89	118.90	153
" 3	113	116	130	127	253
" 4	117	120	129	131	198
Ratio depth to bc carapin	93	84%	83	93	102
" last	63	66	80	70	79
Ratio to carapin to length carpo.	11	11	13	8.1%	13
Ratio hit to length restum (to orbit)	16%	16		12.9	
Ratio depth carapin to length carpo.	10	9.3	11	8.70	13.3
" hit to length low. mandible		11		13.8	
" " " post. length " " (fins setae)		24.9		24	
" " hit to length		11		15.5	
Ratio tarsus to carapineta	88	84	62	45	17
Ratio tarsus to ulna	32	29	25	17	8

$$\begin{array}{r} 150 \\ 984 \\ \hline 2484 \end{array}$$

Skull	
Length	16.9
Snout-vent from orbit	122.2
Length from head	120.7
Depth at naris	16
Depth from lower lobe	9.6
Depth to palates	16.6 (ca)
Depth orbit to supraco.	25.2
Pr orbit	21.6
Length zygoma	44.1
Pr across frontals	23

length 245

Ba ~~perx~~ 16.7

Be d'erb- 12.3

Br sh 9.1

Radius

length 248.4

pinxlor 6.5

Ben Dick 13

Book 5.3

Californica

Length 115.8

Digit 1 34.1

11 2 Pch 52 (6.13.11)

1, 2 Ph 2 50

Right 3 27.3

Tausoneta

28901
Silver

Length ext side 19.8

T. bionans

length 70.8

Brux 8.8 (no constraints
anyway)

Phalanges, length

Ph 1 Dig, 2-15-2 Ph 1 dig, 4-11-1

Ph 2 11 2-15 2 11 2 11 4-9.0

Ph. 1 " 3 - 16-2 3 1. 4 - 7. 3

" 2 " 3-17,3 4 " 4-11,8

" 3 " 3-16.7 Ph 1 dig. 1 15.5"

B. cuneifera 15, equals 8.8-13.8

11 11.0-15.5"

Ratão lumes Tulea

... carbo " "

" Digit 1 " cap 29.4%

Dykt 2 Ph1 " 44.9

11 3 15 11 24.4

11 2 Ph 2 " " 43.1

Tidal Length of day 2 - 30.4

$$3 - 50,2$$
$$4 - 39.2$$

Retro Deg. 2 to tarsus — 153

1. 3. 5. — 253

11. 4. 1. — 198

Ratio of depth to circumference — 102.20

Leant 79

" 67 comes from the length capto 13.70

"depth" " " " 13,3%

Ratio faunae & capies 17%

Pelecanus californicus

Humerus

Length 193
Br. dist 31.0
Depth Dist 36.8
Br. sh 15.1
Br. dist, sh. 26.4
Ulna ~~312.8~~
Length 312.8
Br. prox 23.3
Br. dist 16.5
Br. sh 11.2

Radius

Length 314.2
Br. prox 9.1
Br. dist 8.2
Br. sh 7.5

Carpometacarpus

Length 124.6
Digit 1 sh 43.7
Digit 2 ph. 1 48.0
Digit 2 " 2 46.1
Digit 3 32.8

Tarsometatarsus

Length (ext) 78.8
Depth prox 19.2
Depth dist 14.5
Depth mid dist 10.1

Tibiotarsus

Length 122.7
Br. prox 17.9 (22 to ext. cut)
Depth dist sh 12.8
Br. prox " 8.3

Phalanges (length)

686 { Ph 1, digit 2 - 39.6 Ph. 1 digit 4 - 31.1
Ph 2 " 2 - 29.0 Ph 2 " 4 - 26.7
Ph 1 digit 3 - 41.1 Ph 3 " 4 - 22.4
1030 { Ph 2 " 3 - 34.2 Ph 4 " 4 - 21.4
Ph 3 " 3 - 27.7 Ph 1 digit 1 - 34.3
Br. cuneiform 16.4
dist " 13.2, 13.7

Skull

Length 382.4
Length beak & orbit 219.3
" " " hinge 301.1
Tip beak to ant. edge nares
Length nares 4.8
Length upper edge beak to post. edge nares
Length sulcus from notch to nares
Length zygoma 74.2
Depth beak, center nares
" " to palatag " " 30.8 at ap. depth
Depth " at post. notch 17.3
" diagonal from hinge to edge of mandible
" beak to start of sulcus
Dorsal hinge diag. to start sulcus
Depth from sulcus to tomia, center nares
" " " to dorsal edge " "
Breadth orbit 32.5
Post. edge orbit to supraoccipital 32.5
Mandible
Length

Ratio humerus & ulna 61.7%

" carpo to " 39.7

" Digit 1 " carpo. 35

" Digit 2 Ph 1 " 38

" " 3 to " 26

" " 2 Ph 2 " 37

Total length ped. digit 2 68.6

" " " 3 103.0

" " " 4 101.6

Ratio digit 2 to tarsus 87%

" " 3 " " 130

356 " " 4 " " 129

" gr. depth to br. cuneiform 83.2%

" dist " " " 80

" br. cuneiform to length carpo 13

" gr. depth " " " 11

Ratio tarsus to carpo. 62

" " " " 23

Diomedea exulans

Humerus

Length 407.8

Br. prox 50.4

Depth dist 28.9?

Br. sh 17.6

Br. dist sh. 23.7

Ulna

Length 395

Br. prox 24.8

" dist ext 14.7

Br. shaft 11.6

Radius

Length 393.5

Br. prox 9.0

Br. dist 14.6

Br. sh 5.4

Carpometacarpus

Length 138.8

Total length

hand 275.5

Digit 1

62.5

Digit 2

Ph 1 65.7 Br 13.8 (center on 20)

" 2

" 2 71.0

Digit 3

26.3

Tarsometatarsus

Length 117.0

Depth prox 18.5

Depth dist 17.2?

Depth mid back only 13.5

T. phalangeus

Length 156.3

Br. prox 18.1 (25 to extent on cut)

Depth sh (dist) 8.2

Breadth " (prox) 13.3

Phalanges length

Ph 1, digit 2 74.2

Ph 2 " 2 42.0

Ph 1, digit 3 66.5

Ph 2 " 3 41.9

Ph 3 " 3 28.0

Br. curviform

15.3

Depth

" 10.3 r 13.0

Skull

Length

251.4

" Protrusion to orbit

185.0

" " to hinge

177.3

Tip beak to edge nares

112.0

Length nares

18.05

Length upper edge back of nares

16.3

Diag length sulcus from nostril to nares

14.4

Length zygoma

81.2

Depth beak center nares

30.5

Depth of lateral " "

33.2

" at post notch of pointed mandible

31.0

Depth diag. hinge to edge of "

35.1

" beak to start of sulcus

19.9

Hinge, diag. to start of sulcus

29

Depth sulcus to start of center nares

15

" " to dorsal edge, " "

15.5

Breadth orbit

41.0

Mandible

Length

229.3

Length from sub. to ant on

75.3

vent. border

Depth at ant. edge of art. c.

20.3

" at subus

25.5

Gr. depth

26.2

Length wing

1364.5

1388) 13000
12492
5080

Ph 1, digit 4 55.4

" 2 " 4 34.7

" 3 " 4 27.8

" 4 " 4 23.1

1419

Depth low measured at
anterior large tooth C on chert

Measurements of *Odontophamphornis*

	<i>Pseudodontor.</i>	<i>Odontopteryx</i>
Length of skull	397 401.5	400 (+130 ant.) 150 (30-145?)
Length of rostrum	298 300.0 = 75% 9 total	449 270 (est. 400) 311 = 69900 total
Length from anterior edge of orbit to occiput	88.00 90.00	119? 118 139? 137
✓ from suture to occiput	99	139? 137
Distance from frontonasal suture to anterior edge of orbit	10.6	20
Distance from frontonasal suture to posterior edge of external nares	95.00	90
from ant edge orbit to ext. nares	106.0	110
✓ Length from posterior edge of orbit to occiput	35.00	47
Distance from tip of beak to anterior edge of nares	192.00	213?
Length of nares	15.00 15.6	.08?
Depth rostrum at center of nares	40.0	36
✓ Depth rostrum at posterior tip of maxilla	43.1	40?
Depth rostrum to rostral groove at preorbital notch	33.4	26-28?
Length of rostral groove from preorbital notch to posterior edge of nares	95	
✓ Length of zygoma	85 13	106-113.0? 19
Length of available part of lower mandible	372	314-338@?
Distance from center of suture to posterior end (along ventral border)	106.0	128
Depth at suture	50	45-46?
Depth at articular	18-20/7	26
Depth at center of coronoid process	56	53-56?
✓ Interorbital breadth (frontal)	25	36
Breadth of orbit	53.3	72.6
Breadth sclerotic ring	42.5 x 42.5	
Number of teeth	Sup. 2 post. 11 ant. Low 4 post. 14 ant.	5? beyond nares Sup., 7 Low ant to nares
Largest lower tooth breadth at base	9.9	15 layout is 3rd
height	13.8	12 from base
Largest upper tooth breadth	8.3	15 14 12
height	13.0	17 10 13
Distance between large teeth		
Upper		15mm ant. preorbi notch
Lower		50mm ant. to the above tooth
		25 ant to the 2nd (above) tooth
		45 ant to preorb notch

a Left tooth
b fractured "denticle" with pyrites matrix
inside. No alveolus
c "tooth"

d of larger teeth

~~at tooth~~

f frontal suture fig. 4, groove of ^{fig. 2} lower mandible
along dentary

g longitudinal groove

h articular cups of quadrate ("tympanic")

i outer condyle of quadrate

j

k inner condyle of quadrate

l orbital process of quadrate

m occipital foramen

n nasal suture (fig. 4) notch in fig. 1-2)

o - orbit

v - at Qas (fig. 3)

x-x - vertical ridges of occiput

s crotaphyte fossa

1 occipital condyle
2 exoccipital prominence (fig. 3)
3 cerebellar protuberance
4 paroccipital wall (fig. 1)
5

6
7 parietal

8
9
10

11 frontal

12
13

14

15 upper edge of rostrum, 2 ridges
converging to form # 22

16

17

18

19

20 terminal point of rostrum below
zygomatic

21 median ridge

22

23

24

25

26 zygomatic bar (malar 345)

27

28 "tympanic" (= quadrate)

29

30 articular end of mandible (bottom)
angular

31 surangular

32 combined splenial and dentary

33 orbital process of lacrymal

Table of comparisons

Fossil	Diomedea exulans	Pelecanus calif.
Length skull 16 in.	11 inches	17 in.
Rel. length beak $\frac{3}{4}$	$\frac{2}{3}$	$\frac{4}{5}$
Nares length 16 mm	18 mm	5 mm
Shape beak high, narrow	high, narrow	high narrow to broad flat
No supraorbital fossae	supraorbital fossae present	not present
Length tarsus $4\frac{1}{2}$ in.	$4\frac{5}{8}$	$3\frac{1}{8}$
Rel. length " to ulna 18	29	25
Rel. length phalanges 118% Digit 2 to tarsus 107% (minus ungual)	104%	86%
Digit 1 absent?	absent	present
Wingspread		$8\frac{5}{8}$
Ext. humerus $24\frac{1}{2}$	$16\frac{1}{16}$	
hum to ulna 91% (frag.)	103.2%	83.4%
length ulna 25"	$15\frac{1}{2}$ "	14"
Carpus 10"		
longest feather $15\frac{3}{4}$		
greatest wingspread $13\frac{1}{8}$ " least 13-16 ft	8-10 ft	8-9'
longest feather 41"?	2 ft	21-22" (11 in)

Table of Measurements of
Osteodontornis compared with Diomedea and Pelecanus

U	Osteodontornis	Diomedea exulans	Pelecanus occidentalis	
ULNA	649?			668
Length	650 mm.	395 mm. (15 1/2 inches)	313 mm.	307 14"
Breadth proximal end	32	25	23	25.5
Breadth distal end	13.5	15	16.5	19
RADIUS				
Length	643	393.5	314	350
Breadth proximal end	14.5	14.5	8	11
Breadth distal end	16	9	9	19
CARPOMETACARPUS				
Length	252	139	124.5	137.5
CUNEIFORM				
Greatest height	20	13	13	17.5
Least height	14.5	10	14	14.5
Breadth across tips	22	15	16	17.5
WING PHALANGES				
Digit 1	118	162.5	44	48
Digit 2, phalanx 1	70	66	48	51
Digit 2, phalanx 2	80	71	46	52.5
Digit 3	48	26	33	35.5
TARSOMETATARSUS				
Length	114.5	111	79	85
Depth proximal end	30.5	18.5	19	22
PEDAL PHALANGES				
Digit 2, length width				Digit 1
Phalanx 1	81.5	74	39.5	42
Phalanx 2	54	42	29	30
Ungual	16.5	18.3	14.1	14 15.6
length digit minus ungual	134.5 (107%)	116 (104%)	68.5 (86%)	
Digit 3, length without ungual	145 (134%)	136.5 (123%)	103 (130%)	
Phalanx 1	75.3	66.5	41	44
Phalanx 2	46	42	34	38
Phalanx 3 (space)	24 32.5	28	28	32
Phalanx ungual	15	16.2	13	13
Digit 4, without ungual	150.5 (164.5 with ung.)	141 (127%)	135.5 (170%)	
Phalanx 1	63	55.5	31	33.5
Phalanx 2	37	35	27	29.5
Phalanx 3	26.5	28	22.5	25
Phalanx 4	24	23	21.5	24
Ungual	12 14	13.6	11.5	12
PRIMARY FEATHERS				
No. 1(?)	298?			
No. 2 (?)	292?		301.5	
No. 3 (?)	312 404 to capsum		375.5	
	365			
HUMERUS	542 183% as in Pelican	408 103.2% uln		298 83.4% uln
	670.8 103% as in Diomedea			
	593 mm. actual meas. of frag.			

Measurements continued

Fossil

D. exulnas

P. occidentalis

Length right ulna	647	395	312.8
Length left ulna	650		
Breadth prox. ^{right} left ulna	32.0	24.8	23.3
Breadth dist. " "	13.5	14.7	16.5
Length left radius	643	393.5	314.2
Breadth distal end	16.0	9.0	9.1
Breadth proximal end	14.6	14.6	8.2
Breadth cuneiform	20.6	15x3	
Gr. height cuneiform	20.2	13	13.2
Least " "	14.5	10.3	13.7
Br. across tips	21.7	15.3	16.4
Length left carpometa.	252 ^{38% of ulna}	138.8 ^{35% of ulna} 34% of humerus	124.6 ^{39% of ulna} 64% of humerus
Length wing digit 1	117.8 ^(46.8% of carpus)	62.5 ^(45.1% of carpus)	43.7 ^(35% of carpus)
" " " 2/1	70.1 ^{27.8% of carpus}	65.7 ^(48% of carpus)	48 ^{38.5% of carpus}
" " " 2/2	80.3 ^{31% of carpus}	71.0 ^{51% of carpus}	46.1
" " " 3	47.9 ^{19% of carpus}	26.0 ^{19% of carpus}	32.8
Left humerus) part present	407 ^{48.2% of ulna} fragment	407.8 ^{103% of ulna}	7293? ^{61% of ulna}
Length tarsometatarsus	114.3 ^{85% of tarsus}	111.	78.8
Depth proximal end	30.4 ^{25% of tarsus}	18.5	19.2
Length digit 2 (foot)	134.5 ^{115% of tarsus}	116 ^(104% of tarsus)	68.6
minus ungual			
Length digit 3 (foot)	145.1	136.4	103.0
minus ungual			
Length digit 4 (foot)	150.4	141.0	135.6
minus ungual			

PROPORTIONS

Ratio tarsometatarsus to carpometacarpus 45 84% 62

Ratio tarsometatarsus to ulna 17 29% 25

Skull (15 5/8 inches) 397

Ratio ulna to skull length 165%

Br cuneiform to length carpus 86%

157

105 mg of tarsus

11.90

81%

13%

131
1143) 1504
1143
3610
3429
1910

Birds possibly related to Osteodontornis

low. Eocene (London Clay) - Argillornis emuiensis (Bowerbank)
(= A. longipennis Owen) See Owen Quart. Journ. Geol. Soc. London
vol. 34 p. 124-131, Pl. 6, figs 1-3, 7-12, 14; also Ann. Mag. Nat.
Hist. London (5) 2, p. 98. (See also Lambrecht p. 282-284)

Humeri (RTL frag.)

Skull frag. described later by Owen (1880 Quart. Journ. Geol. Soc.
London 36: 23-24, Pl. 2, figs 1-7.

Ulna described by Lydekker (Cat. Fish. Brit. Mus. 47-50
1891, fig. 11)

Skull 135 fig of skull only, probably 190 mm. long.

Owen compares skull to Diomedea - has a transverse
hinge bet. frontal & rostrum & lacks supraoccipital process.

Lydekker thinks these characteristics put skull with Sula.

Owen found on the right side "the outline of four small
vertical pits, like sockets of teeth but filled with matrix."

Humerus more Sula than Diomedea like

Ulna 468 mm long

Pelicanus?
Miocene? Vancouver Id. Cyphornis magnus Cope 1894

Jour. Acad. Nat. Sci. Phila. (2) 9: 449-452 pl. 20 figs 11-16

See Wetmore 1928 on systematic position Canada Surv.

Geol. Ser. Bull. #49. pp 1-4 - figs 1A-B.

Tarometatarsus fig. Hypotaenidia resembles Sulidae

Miocene So. Carolina - Palaeorhynchoides miocaenus Shufeldt 1916

Geol. Mag. 6(3): 343-347, pl. 15. See Wetmore 1917 Jour. Geol. 25:
555-557 pl. 1

Lenox. Wetmore says size somewhat larger than Pelicanus
erythrorhynchus ~ P. onocrotalus. Shows resemblance to
Sulidae + reminds to Amblypterus + Phalacrocoracidae (B. dub.)

end 36 mm ±

Miocene France - Pelagornis miocaenus Sactet 1857. C.R. Acad. Sci.

Paris, 44: 736-741. See Miller Edwards 1867-68 pp 273-275,
pl. 45 figs 1-2. Humerus 580 mm long resembles Diomedea

the ME says more like Sulidae. See Lambrecht p. 282

Brooksb. bones in suborder Odontopterygia
 8.12.46 Pelagornis miocaenus Sart. 1857
 580 mm. Long humerus [593 mm. long] (non called mid mid)
 Osteodonto (non called mid mid)
 Brooksb. cat.

- as in Sula { ① small prox end
 ② weakly developed pectoral crest
 ③ Absence of ectepicondylar process [better developed in Osteodonto] }
 ④ Absence of olecranon fossa (as in Pelicanus)

X See fig 1-7 Pl 45 of Milne Edwards
 Sex + (vol. 1) 2-3-276 " "

pectoral ridge
 122, 3 (21%)
 glenoid

X Also Lydekker p. 47

[Pelagornis delfortii at Marseille Mus.)
 = P. miocaenus

EOCENE

Argillornis longipennis Owen 1878 (A. emarginatus Sheph. 1854)
 Gen. diag. Ulna with well developed olecranon fossa
 Anisodactylus resembles Phalaropus but has alveoli for teeth (!)
 Anisodactylus

[Brooksb. puts with Elpteryx nipscai Andrews in
 Suborder Sulae, family Elpterygidae Lambrecht]

Type is shaft of humerus (called a "tetracterus")
 circumference of shaft = 1 inch Brit. Mus. 38941

Two other humeri (Brit. Mus. A. 5-9) were Owen's types
 of Argillornis longipennis Quart. Journ. Geol. Soc.

Ref. for Humeri → London 34: 124-131, pl. 6, figs 1-3, 7-13, 14.

A5 = prox right very much like Sula says Lydekker.

A6 = 2 portions of dist left (condyles missing)

A7 = mid of shaft

A8 = prox left (resembles fig. 9 Pelagornis humerus)
 also resembles Sula says Lydekker

A9 = shaft left with tip of deltoid crest.

Another larger humerus in Woodwardian Mus. = Megalornis
 Left ulna, prox end (Brit. Mus. A 94) resembles Sula
 at least 34 mm across cotylae (illus in Lydekker 1
 nat. size, with broken
 ext. cotyla measures 16.8
 skull only

Argillomys continued:

Skull - transverse fronto-nasal suture (as in Sula)
a lateral groove on rostrum near alveolar
border. (Lydekker says "accords closely with
shelly Sula" (1) in which groove formed
by junction of 2 portions of horny sheath

[Note: doesn't show on bone, however 141]
also (say Lydekker) lacrymal has similar
depression on ext. surface bet. expanded
extremities. Position ^{of} post. nares as in Sula
(Differs from albatross)

Owens

1880

Quest. Jour.

36: 23-24 pl 2, fig 1

London

have been

formed from

lateral

artery

1886

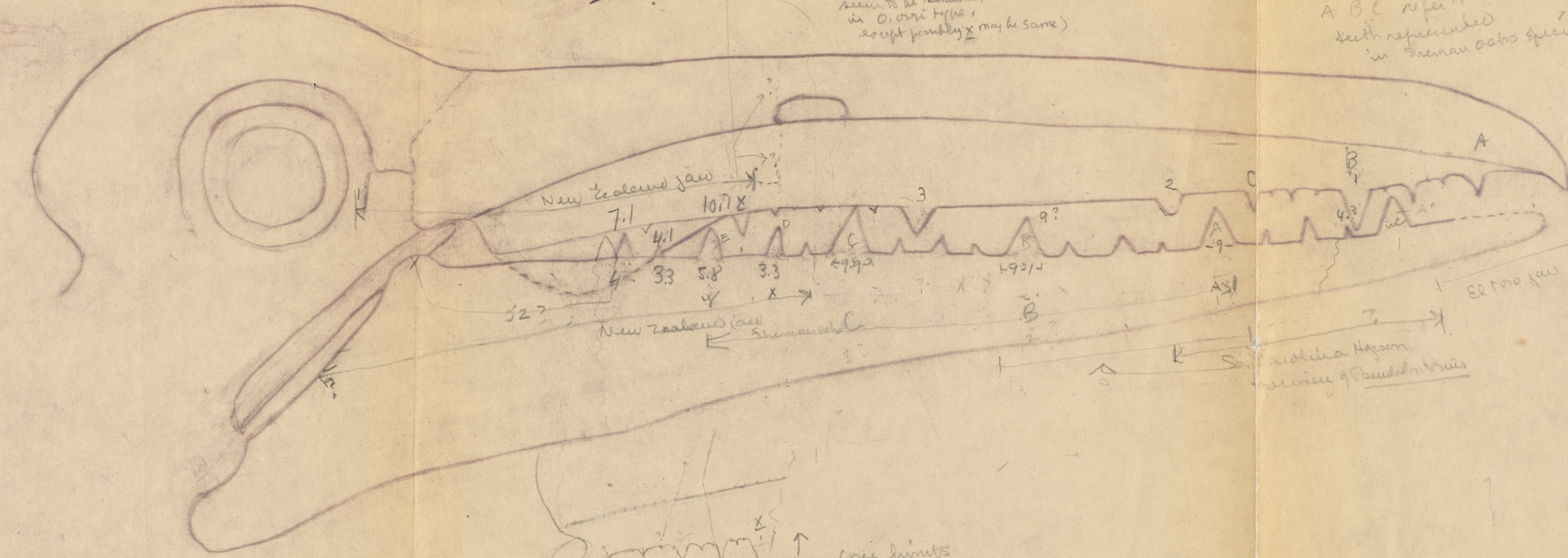
too far comparable
to layout upper
in NZ

x, y lower teeth
of New Zealand
bird
(upper of NZ bird
seem to be rounded
in O. orri type,
except possibly x may be same)

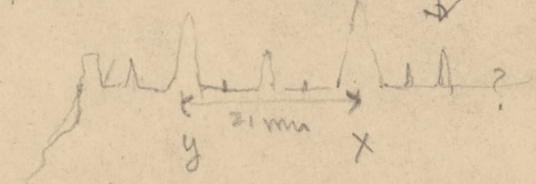
? 2, 3 = large teeth
of Pseudobornia

typical type

A B C refer to
teeth represented
in Sphenacanth specimen

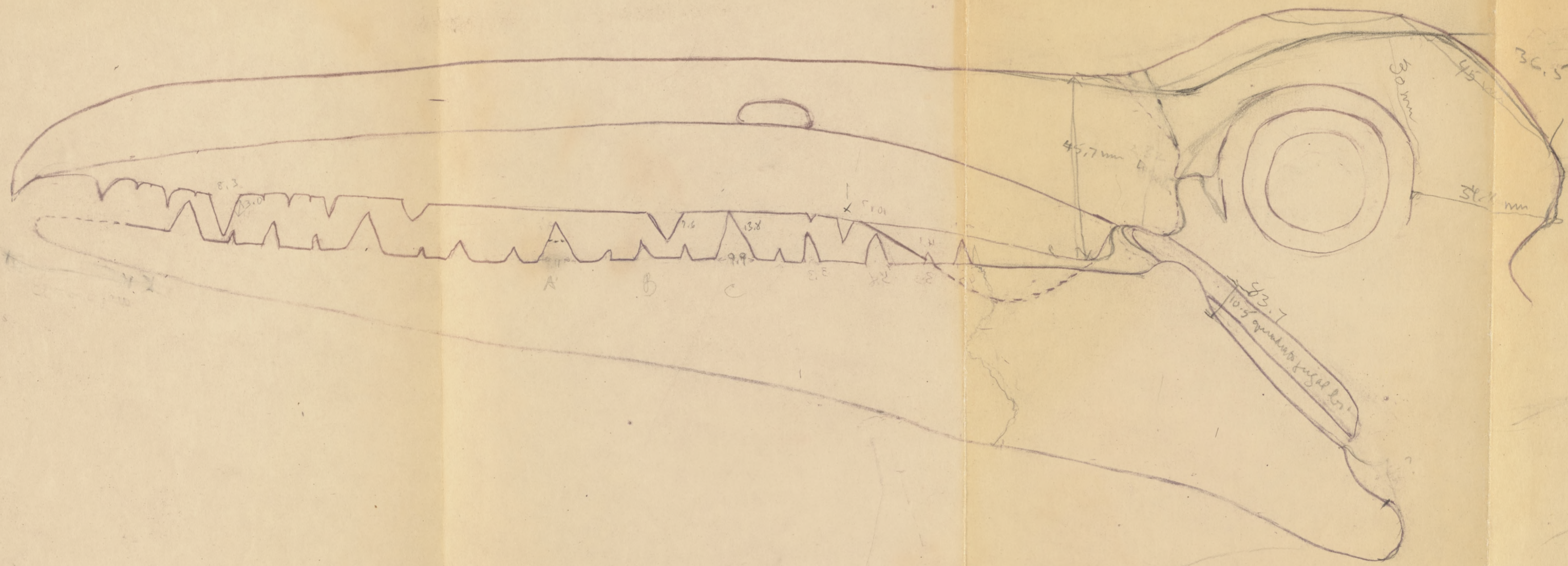


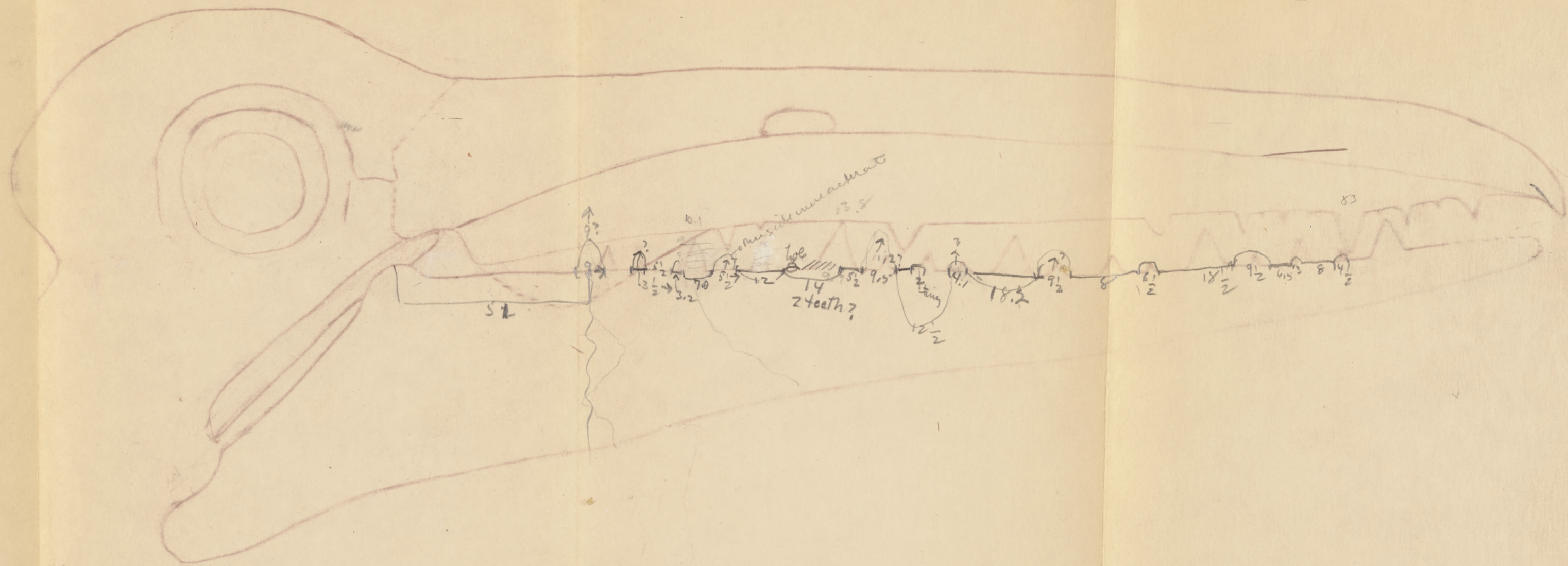
upper (see limits
New Zealand lower on drawing
above)



Shull of Type
Osteodontoformis orri
Sta B. mus

Areas available
on other skulls of this
family indicated on
drawing above.
H 1966





Frigate-Pelecaniformes - Steganopodes - Totipalmates

- ① All toes webbed together fully. Large hind toe
 - ✓ ② Nostils minute, rudimentary or abortive
 - ✓ ③ Tonia sometimes serrate (horny part only)
 - ④ Usually a long sulcus on upper mandible along side culmen, nearly to tip of bill
 - ✓ ⑤ Bill usually hooked with more or less distinct nail
 - ⑥ Very great pneumatization (e.g. pelicans)
 - ✓ ⑦ Desmognathus palate
large spongy maxillopalatines
-
- ✓ Albatross - Procellariiformes - Tubenarcs
- ① Very small hind toe, functionless - sometimes absent
 - ② Outer bill consists of several horny pieces separated by sutures.
 - ✓ ③ Feet short, with long fully-webbed front toes
 - ④ Palate desmognathous
 - ⑤ Top of skull with large depressions for supraorbital glands.

Chars of Telesauriforme

Short ~~Tarsus~~ ^{tarsus} ~~pedal~~ ^{plus} "feet" - notably the Ligate

Ligate ^{tarsus} less than half of cubitus "

Phaethon tarsus nowhere near that of forearm

Booby

Coriunt

Andys

forearm = leg + "cubose" units

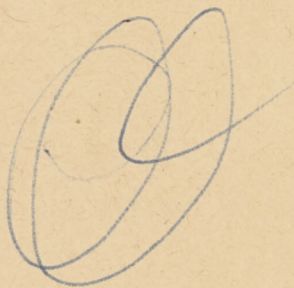
Tarsus ^{short} compressed from front to back so that its breadth is greater than its depth.

crest + troughs for muscles pronounced.

Trochlear same length approx. Pro. trah. of int. side

is always lower than the external (opposite of ducks)

Digits long - surpassing by a great amount the length of the tarsus



Differs from Pseudodontomys

No. & size of teeth (3 small but large)

Upper does not agree with lower

Size of ext. nares (larger & deeper)

more slender zygoma

less depth of brain case

Similar to Pseudodontomys

ascending groove then parallel

very deep lower jaw

underhanging palatine

absent supraorbital sulci

coronoid process?

size

Differs from Odontopteryx

sheaf on top of beak in Odontops

Narrow frontals of "

absence of nares in "

teeth more pointed

forward projects " "

groove of lower jaw

parallels border in S.M. but

up & down in Odont.

size?

check skull contours
again - frontal, lacrymus
rostrum, ~~maxilla~~ notch
bones, occipital process
lower front teeth in slab
meas. leg bones in slab (spec)

134
24
210

CHARACTERS OF ODONTOPTERYGIA PARALLELED IN LIVING AVIAN ORDERS

Character	FOSSIL ORDER	LIVING AVIAN ORDERS		
	Odontopterygia	Procellariiformes	Pelecaniformes	Anseriformes
Narrow, deep rostrum	All three genera	X		
Small external nares placed well forward	All three (?) genera	X(<u>Diomedea</u>)		
Longitudinal rostral groove	All three genera	X(<u>Diomedea</u>)	X	
Rostral groove situated at or below preorbital notch	All three genera	X		
Absence supraorbital fossae	All three genera		X	Only faintly indicated fossae
Desmognathous palate	<u>Pseudodontornis</u> (palate not visible in other 2 genera)		X	
Maxillopalatines inflated	<u>Pseudodontornis</u> and <u>Osteodontornis</u> (not visible in <u>Odontopteryx</u>)	X(<u>Diomedea</u>)	X(<u>Pelecanus</u>)	
Maxillopalatines form inflated central ridge	<u>Pseudodontornis</u> (not visible in other 2 genera)	X (but with narrow break between right and left)		
Palatines separate and enlarge vertically	<u>Pseudodontornis</u> (not visible in other 2 genera)	X		
Presence of sulcus on lower mandible	All three genera			X
Proportions ulna ^{long with narrow end} and cuneiform ^{small}	<u>Osteodontornis</u> (not represented in other fossils)	X		
Absence pedal digit 1	"	X		
Pedal digits 2-4 long	"	X		
Int. ridge hypotarsus large	"		X	

CHARACTERS OF ODONTOPTERYX, PSEUDODONTORNIS AND OSTEODONTORNIS COMPARED WITH THOSE OF LIVING ORDERS OF BIRDS

FOSSILS

NEAREST LIVING ORDER

Characters in which the three fossil genera are alike

Possession of bony "teeth"

NONE

Rostrum

Longitudinal rostral groove

(Diomedea) ~~of~~ Procellariiformes ~~Procellariid~~
Groove present in Pelecaniformes but more dorsal in position

External nares small and well forward*

Small in Pelecaniformes, but far back
Forward in Procellariiformes, and small in Diomedea

Rostrum narrow and deep

(Diomedea) ~~of~~ Procellariiformes

Frontals

Narrow over the orbits and no supraorbital fossae

Supraorbital fossae absent in Pelecaniformes but frontals broad. Frontals narrow in Anseriformes but fossae slightly indicated. Various orders, but NOT Pelecaniformes

Temporal fossae reduced

Sulcus present on lower mandible

Anseriformes

Characters found in Pseudodontornis and (in part) in Osteodontornis but area not visible in Odontopteryx in

Maxillopalatines inflated so as to be visible below upper tomium

(Diomedea) ~~of~~ Procellariiformes and to a lesser extent (Pelecanus) ~~of~~ Pelecaniformes

Inflated maxillopalatines united to form central ridge flanked by lateral grooves (area not visible in Osteodontornis)

Diomedea of Procellariiformes except small slit separates maxillopalatines. Maxillopalatines united in Pelecaniformes but no ridge or lateral grooves

Palatines separate and vertically enlarged (area not visible ~~xxx~~ in Osteodontornis)

Separate in all Procellariiformes, vertically enlarged in Diomedea. United in all Pelecaniformes; vertically enlarged in Pelecanus.

*Notch on rostrum of Odontopteryx thought to represent posterior border of nares.

- 30 -
TABLE II

CHARACTERS OF ODONTOPTERYX, PSEUDODONTORNIS AND OSTEODONTORNIS COMPARED
WITH THOSE OF THE PROCELLARIIFORMES AND PELECANIFORMES

Characters of skull, visible in all three fossil genera, except as noted

PROCELLARIIFORMES

PELECANIFORMES

Bony tooth processes present	NO	NO
Relatively heavy zygoma	NO	NO
Frontals narrow above orbit	NO	NO
Supraorbital fossae lacking	NO	YES
Temporal fossae reduced	MODERATELY	NO
Straight frontonasal suture	MODERATELY	YES
External nares placed well forward of frontonasal suture (providing notches on rostrum of <u>Odontopteryx</u> represent posterior borders of nares)	YES	NO
Longitudinal rostral groove present	YES (in DIOMEDEA)	YES (but position different)
External Mandibular ^{Sulcus} groove present	NO	NO
^{separate and} Palatines deep vertically (seen only in Pseudodontornis)	YES (Diomedea)	Not separate; YES (Pelecanus) deep in Pelecanus
Palatal region inflated (seen only in Pseudodontornis and Osteodontornis)	Yes (Diomedea)	YES (Pelecanus)
Characters of limb elements available only in <u>Osteodontornis</u> ^{Prominent ectepicondylar process of humerus}	More prominent YES	NO
Ulna long with narrow ends	YES	NOT AS SLENDER
Cuneiform small	YES	NO
Straight, short unguals	YES	NO
Pedal digit 1 absent	YES (or markedly reduced)	NO
^{Internal calcaneal ridge longest}	NO	YES
^{Internal cranial crest moderately high pointed}	Pointed but higher	NO

FOSSILS

NEAREST LIVING ORDER

Characters of limb elements revealed only in Osteodontornis (except as noted)

Ulna long with narrow ends
 Olecranon low in Osteodontornis
 Olecranon higher in ulna presumably associated
 with Odontopteryx

Procellariiformes
 Procellariiformes

Pelecaniformes

Pedal digit 1 absent

Procellariiformes (Digit 1 large in Pele-
 caniformes, and present but small in
 Anseriformes)

Unguals small and nearly straight

Procellariiformes

Internal ridge of hypotarsus enlarged posteriorly

Pelecaniformes

Characters in which Odontopteryx differs from Osteodontornis and Pseudodontornis

"Teeth" slanting forward, not vertically placed

NONE

Zygoma longer and more slender

Many orders (Osteodontornis and Pseudod-
 ontornis distinctive in short, high zy-
 goma)

Bordering line between occipitals and parietals a
 narrower arch

Lower mandible narrower dorsoventrally behind mandibular
 suture

listed below are the characters which can be compared
^{shells of these}
 in the ¹ two genera and the newly described *O. ori.*

	<i>Odontopteryx</i>	<i>Pseudodontomys</i>	<i>Osteodontomys</i> <i>Odontomys</i>
Rostrum			
Longit. groove	present, slightly ascending	present, ascends then goes straight	same as <i>Pseudod.</i>
Ht. rel. to br. front-nas. suture	100%	153%	150%
Ht. to ext. length	14.4%	12.8	21-24%)
Ht. rel. to width orbit. Br.	166	111	172
Ext'd length relative to total length of skull.	55-65%?	69%	75%
Position of nares	oral? above groove 32% about 2/3 dist. from snout to tip	slit in groove 28-30% of dist. from snout to tip	oral above groove 29% of distance snout to tip
Frontals			
Interorbital space	narrow 24% of post. br. no supraorbital fossae	44% of post. br. 30% of supraorbital fossae	narrow 31% of post. br. no supraorbital fossae
Temporal fossae	feeble	slight	absent or slight
Lacrimal	short post'ly	perpendicular	perpendicular
post orbit / orbit	73%	62-64%	65%
Zygoma / cran.	77%	84%	85%
Br. to length zygoma	15%	16%	10%

3rd Alibi

absent supraorbital fossae

absent or small temp fossae

Longit. rostral groove

Possession of ^{toothless} projections

Possibly nares on or above same about 3/20
dist. naris & tip.

Large orbit with sclerotic ring

Uulite —

Odontopharynx

Slender zygoma

Mandible naris
descends postly

Groove descends

Teeth absent from

Caudal

heavy zygoma

ventral

Longit. process

Teeth vent

Odontopharynx

mod heavy zygoma

vertical

Longit. ? process?

Teeth vent

Adontorhynchus

Pelecaniformes

Procellariiformes

supraorbital fossae

absent

absent ✓

present

~~postorbital~~
ext. nares

clearly formed &
well forward of
frontonasal
suture

absent or reduced
close to fronto
nasal suture

clearly formed
& well forward
of frontonasal
suture

temporal fossa

reduced

large

moderate

low elevation
of nuchal

low

high

low ✓

~~pygostyle~~
~~long bone~~

~~very long & slender~~

moderate

~~very long &~~
~~very small~~ ✓

size of cuneiform

very small

well developed
~~process~~

absent ✓

Pedal phalanges
hind toe

absent

all digits
(minus ungual)
exceed tarsometatarsus
in length ✓

proportions of
foot

all digits
(minus unguals)
exceed tarsometatarsus
in length

second digit
(minus ungual)
shorter than tarsometatarsus

hypodermis of
tarsometatarsus

~~composed of~~
more than 2
ridges; internal
longest
internal ridge
markedly greater
in post. extent

~~composed of~~
ridges; int. longest
internal ridge
greater in
extent ✓

~~composed of~~
2 ~~main~~
~~apical ridges~~
int. & ext.
ridges nearly
~~prominent in~~
development
only slightly
more extended
than ext. ✓

Lab Vibrofool

		10.37
Rolliflex camera	234.02. inc 4.07	238.09
Gray Herbarium (with libran)		100.00
Idem (1/2) Indians of Calif.		145.72

Misc. not exhibit

1.58	machines dup.	field
18.57	can rock Ent.	field

2.56 fossils Lake Chapala

20.70 reprints of newspaper

55.00 dinosaur models

7.84 "Radio products"

Exhibits

Ent Bubbles	41.60	
" "	3.90	
" "	3.73	49.23
	49.23	

Droit Nab.	4.48	
" "	2.74	
" "	1.47	8.69
	8.69	

archeol. objects 20.00

mineral light 186.69

Geyser device 100.00

Misc

11.81	318.50
318.50	

376.42

Hancock Park South Amm RLB

posters 62.40

billboard 25.48

leaflets 267.09

354.97

Adontognathus

Pelecaninus

Procellarius

supraorbital fossae

absent

absent ✓

present

~~present~~
ext. nares

clearly formed &
well forward of
frontonasal
suture

absent or reduced
close to fronto
nasal suture

clearly formed
& well forward
of frontonasal
suture ✓

temporal fossa

reduced

large

moderate

~~low~~ olecranon
of ulna

low

high

low ✓

~~very long~~
~~very small~~

~~very long & slender~~

~~very long~~

very small ✓

size of cuneiform

very small

moderate

~~well developed~~
~~present~~

absent ✓

Pedal phalange
hind toe

absent

proportions of
foot

all digits
(minus unguals)
exceed tarsometatarsus
in length

second digit
(minus ungual)
shorter than tarsal
metatarsus

all digits
(minus unguals)
exceed tarsal
metatarsus in length ✓

hypodermis of
tarsometatarsus

~~composed of~~
more than 2
ridges, internal
longest
internal ridge
markedly greater
in post. extent

~~composed of~~
ridges, int. longest
internal ridge
greater in
extent ✓

~~composed of~~
2 ~~nearly~~
~~equal~~ ridges
int. & ext.
ridges nearly
prominent in
development
only slightly
more extended
than ext. ✓

Translation from (Lambrecht)

14
First of all it must be repeated that Pseudodontornis did not possess genuine teeth. The existing toothpicks stand structurally near the "file-like edge" or "notched file" of the parrot & the Merydal, since the ^{incisive} ~~incisive~~ ^{are not} ~~teeth~~ limited ~~to~~ only to the horny edge of the beak but ^{spread} also to the bony substance.

Functionally speaking the toothpicks of Pseudodontornis resemble the ^{tooth} notches of the fish eating birds (Arididae, Anas, Mergus). They suggest a stronger "bite".

Since the entire skull is highly pneumatic & all bones of the skull are very thin, the biting or crushing of prey does not seem in any way likely. Also the characteristic palatal "teeth" or "cups" or "edge" or "comb" is

so that it seems not so much to ^{the bite} as more to strengthen the greatly lightened upper beak

If we now turn again to *O. taliaferri* we understand that this latter with respect to *O. longirostris* stands in the relationship of another species. Then as we have seen, both agree in most essential characters, also. *O. taliaferri* stands in strange contrast to all known birds and shows marked accord with the *Steganopteres* *Tubivores* and *Anseriformes*, as *O. longirostris*. While in agreement with the latter, however, it ~~lets~~ ^{lets} itself be aligned with none of this group and represents a collective form standing ^{to be} ~~equivalently~~ ^{equivalently} separate from each of the three. It seems demanded that English & Brazilian examples be brought together under one and the same order and ~~to establish~~ ^{to establish} a new order - *Odontopterygia* for both, whose single representatives are at this time *O. taliaferri* Owen & *O. longirostris*, n. sp.

I must oppose this expectation of Skulshin's that the *O. longirostris* or *P. longirostris* skull is different from Owen's *O. taliaferri* in the course of the coronal suture in structure of the Quadrate, in ^{position} ~~position~~ of the quadrate foramen in structure of the mandible and especially in the form of the tooth-peg, that both cannot be brought together in a genus, indeed not in the same family or order.

We have no justification to change the systematic position of Owen's *O. taliaferri*; this form remains as before in the proximity of the *Steganopteres*. The upper jaw of *Pseudodactylops* resembles the upper jaw of

The Procellariiformes, the ~~or~~ quadratus the
Gruiformes, the palatal ridge Phaeocephalus,
the tooth pegs & the skull in general represent
however an entirely one-sided & highly specialized
form, concerning whose relationships we, lacking
a similarly built form, cannot speak with
certainty.

The skull described by Spulski & usually
described here resembles in the position of its quadrates
the Gruiformes, in the position of its upper
maxilla in part the Alcedinidae & Procellariiformes
through its highly specialized palatal ridges
the Accipitres & Phaeocephalus, but can
neither on the basis of the here mentioned
characters, nor on the basis of its secondary
tooth structure be incorporated in one of the
now known bird families.

From Lambrecht -- Hanbuch

Pseudodontornis differs from Odontopteryx toliapicus in the verlauf of the coronal suture, the structure of the quadrate the position of the quadratojugal, the structure of the mandible and especially in the form of the tooth pegs. It differs so much that the two cannot be in the same genus, perhaps not even in the same family or order.

We have no ground to change the systematic position of Odontopteryx toliapicus; this form remains, as before, in the neighborhood of the Steganopodes. The upper beak of Pseu odontornis resmebles the upper beak of the Procellariiformes, the quadrate resembles that of the Telmatoformes, the palatal ridge that of Phoenicopterus, the tooth pegs and skull, however represent an entirely different and highly specialized form whose relationship is not certainly known.

Although the gigantic size of the skull (430 mm.) suggests a flightless bird such as Phororhacos or Gastornis, the high pneumaticity ~~indicates~~ the testifies against the ratite nature of the bird: Pseudodontornis can have been as good a flier as the Pelecan, for example. Without the structure of the fore and hind extremities, this question naturally remains unsolved.

Just as Pseudodontotnis probably was a good flier, so must we suppose a pelican-like habits for it. Its gigantic skull make it seem likely that the neck formed an S as in most long-beaked birds. The good development of the sclerotic ring whose spur remains in the orbit, indicates that Pseudodontornis ~~was~~ also swam well, and fed on fish

SKULL

The most markedly characteristic elements are the skull and jaws. The rostrum somewhat resembles that of the albatross or frigate bird except that the culmen has a more convex contour. The mandibles are clearly distinguishable from those of either of the living birds in the fact that the edges are "toothed". These teeth, however, are not composed of dentine and set in sockets but are instead projections of the jaw bones themselves. The larger porjections can be carefully examined and are continuous with the jaw bone and composed of the same structure. Many of the projections are v ry small and have disintegrated leaving small cavities capped over by matrix. At first these appeared to be alveoli, but careful examination shows them to be at the edge of the jaws, projecting away from the jaw not into it.

The upper beak is marked throughout its length by a sulcus which divides the mandible into nearly equal parts dorso-ventrally. This sulcus begins posteriorly at the angle formed by the junction of the maxillary and the nasal and slopes upwards for a distance of 108 (?) mm. to the small nasal opening. ~~maxillary~~ The cranial portion of the skull is badly fragmented so that exact contours are not available. Overall length is estimated as at least 420 mm. The upper mandible measures 330 mm. along the somewhat convex culmen.

central mass has disintegrated, leaving an outer harder layer which is continuous with the edge of the jaw. The largest tooth in the lower jaw (present on both rami), however, shows clearly the bony structure of which it is internally composed. This closely resembles that structure of the spongy bone inside the more compact surface bone of the jaw. Both upper and lower mandibles show this internal spongy structure as the cleaving of the slabs resulted in a longitudinal sectioning of the skull.

The teeth are nearly conical in shape, ^{with a tendency in some for} though one side ~~may~~ be slightly flattened. ^{By comparing the rami of the lower mandible it would seem that each side of the} There are at least 18 "teeth" in the lower jaw, of ^{has a potential of at least 18 teeth, 7 of which} which five are larger than the rest. These ^{larger "teeth" appear to be} are approximately (though not exactly) evenly spaced. Most of these larger ^{projections} teeth are flanked on either side by very small projections, and between these ^{one of} a medium-sized "teeth". It is likely that there were other "teeth" at the anterior tip of the jaw, opposite to those of the upper mandible, and also that two areas posteriorly in which the spacing is uneven also contained "teeth." The total number of lower projections, might, therefore be increased to 22 or 24.

Owing to the way in which the upper mandible is sectioned, the teeth above are less clearly discernible than those of the lower jaw. It appears, however, that there were more small projections between the large ones above than below. Some of the small projections appear as mere spines on the edge of the jaw, but this appearance may be due to the "tooth" having been sectioned at its extreme edge. This theory is substantiated by photographs of the skull before any preparation. Faintly discernible are the impressions of what appear to be longer projections near the anterior tip of the rostrum and again about midway back on the jaw. In order to determine the true nature of these impressions, however, it was necessary to probe into them before the actual bone was encountered. Further

so outstanding that ~~it~~ even general characters are of value in describing it.

long-winged, short-legged
The skeleton represents a ~~very large~~/flying bird with long jaws bearing tooth-like projections. Full length measurements can be made of ~~both~~ ^{both} ulnae ~~and~~ ^{the right} radii, ~~1~~ ^{the right} carpometacarpus, and phalanges of the ~~left~~ ^{right} side. Neither humerus is complete, but ~~by~~ ^{a moderate} estimation of its length ~~has been~~ added to the lengths of the other wing bones shows the skeletal structure of ~~the~~ ^{one} wing to have been something over 5 feet in ~~length~~ extent. ~~Estimated~~ Breadth of the wing elements, however, is relatively small, the proportions suggesting the long, slender bones of the albatross.

~~The leg bones only extend some~~
(114 mm.)

The length of the tarsometatarsus/shows the leg to have been ~~very short~~ relatively very short for this long-winged bird, although ~~such~~ ^{such} as in ~~the~~ diminutive proportions ~~of~~ the Frigate Bird. The three toes visible are long. There is no sign of an inner toe, although it may ~~be~~ ^{part of the} be still in the matrix.

~~The most remarkable character of this~~ ^{which is preserved} skull is approximately 404 mm in length. As the tip bends downwards

400
The remarkable skull is approximately ~~405~~ mm. in length, with ~~3/4~~ ^{the extreme tip of the beak is overlain & crushed} of which is rostrum. ~~Both upper and lower mandibles~~
By The left ulna but sufficient of the upper portion is present to indicate its anterior extent & to indicate that it curved downward
There is no similarity ~~however~~ with the type of extended rostrum

found in the pelican, the shape being rather more similar to that of the albatross. Quite distinctive from either pelican or albatross are the edges of the tooth-like projections ~~which~~ which occur on both upper and lower mandibles. These "teeth" are irregular in size and their outer bony surface is apparently continuous with the bone of the jaw; there are no alveoli. In most of the teeth the ~~central~~ ^{leaving an outer, harder layer which is continuous with the edge of the jaw} mass has disintegrated, ~~but~~ ^{present} the largest tooth in the lower jaw (on both rami) ^{however} shows ~~the~~ clearly the bony structure of which it is composed. This ~~closely~~ ^{of the bony base inside the surface of} resembles the structure of the lower jaw, ~~below it~~ ^{It is presumed that}

This closely resembles the structure of the spongy bone inside the ^{more} compact ^{bone} surface of the lower jaw. Both upper and lower mandibles show this internal spongy structure as the cleaving of the slabs resulted in a longitudinal sectioning of the skull.

There are at least 18 "teeth" in the lower jaw, ^{These are not} entirely, but approximately evenly spaced ~~more or less with the usual irregular spacing of small teeth~~

There are at least 18 "teeth" in the lower jaw, of which five are larger than the rest. These are approximately (though not exactly) evenly spaced. ~~Between each of these five large teeth~~ Most of these larger teeth are flanked on either side by very small ^{projections} "pegs", and between the small ^{these} ~~pegs~~ a medium-sized ^{"tooth"} "peg". It is ~~quite~~ likely that ~~there were~~ ^{more than 18 teeth in the jaw and that} there were other teeth at the anterior tip of the jaw, opposite to those of the upper mandible, and also that ^{areas} two ~~areas~~ ^{spaces} posteriorly in which the spacing is uneven also contained these projections. The total number of lower teeth, might therefore be increased to 22 or 24.

Owing to the way in which the upper mandible is sectioned, the teeth above are less clearly discernible than those of the lower jaw. ~~Seemingly~~ It appears, however, that there were more small projections between the large ones above than below. Some of the ~~small~~ small ones appear as mere spines on the edge of the jaw, but ~~may~~ this appearance may be ^{due to} ~~cutting into the teeth~~ ^{the teeth projections having been sectioned at the} ~~the extreme outer edge of the projection.~~ This theory is substantiated by photographs of the skull before ~~any~~ ^{the} preparation. Faintly discernible are ^{the impressions of} ~~the large~~ ^{near} ~~projections which~~ what appear to be ~~the longer~~ longer projections at the anterior tip of the rostrum and again about mid way back on the jaw. In order to determine the true nature of these impressions, however, it was necessary to probe into them before the actual bone was encountered. ~~With the~~ Further ~~the~~ complicating the task of discerning the upper "teeth" is the fact that the ~~bones of the~~ radius and humerus of the right wing are jammed into the palatal area ^{and have apparently destroyed any teeth that may have been present there.}

Discussion

Compared with Pseudodontornis the rostrum of Osteodontornis is deeper (dorsoventrally) and probably shorter. The tip is missing in the specimen of Pseudodontornis and its length was originally postulated (Spulski) at 400 mm. In the light of the character of the beak of Osteodontornis, however, this figure is doubtful and an estimate of 308 mm. seems more credible. The rostrum of Osteodontornis measures only 297 mm. Altho actually shorter than that of Pseudodontornis it is relatively longer - equally 75% of the total length of the skull as contrasted with 69% in Pseudodontornis.

James

~~0.015 m~~
~~0.015 cm~~
~~0.015 dec.~~
~~0.015 mm~~

$$212 \overline{) 34006}$$

$$\begin{array}{r} 212 \\ \hline 1280 \\ 1060 \\ \hline 220 \end{array}$$

$$\begin{array}{r} 18 \\ \hline 212 \overline{) 4000} \\ 212 \\ \hline 1880 \end{array}$$

As in reptiles, most birds have 14
sclerotic plates. The least # is 10, the
most 17. (Braun, 1891) A bird without a
sclerotic ring does not exist, at least recently.
The form of a single plate is very variable.
Usually the single bone is somewhat like a
Trapezoid, occasionally also forming a broad
hexagon, on the other hand, more than
twice as high as broad in the long-
funnel-eye of an owl.

As the illustrated recent birds show, the
cornea does not always join the sclerotic
ring, but ^{often more} lies between the sclerotic ring
& the cornea a very strong thickening of the
sclera. An especial example with
the pterosaurs. The sclerotic ring of the
eye of Acromegium is free lying
on the apex of a young alligator it is not yet united to
the edge of the ring, the (13 or 14) bony plates are
proximally serrated. The plates of one eye side
are flat in this eye, only weakly
in contact the distal ends are straight.



The sclerotic ring of the adult alligator (45) consists of
14 plates which are curved outward as in Rhipidosteus
(46) but also as in the other birds.

But on the one hand the plate of the eye of one diurnal raptor, such as that of the eagle, are oblong (49c) and its eye is for ~~it~~ ^{use} a telescopic eye. — on the other hand the 14 plates in the eye of the night flying Pigeon, *Scops scops* (p. 52), are not in the least as high as that of the eagle, only more steeply placed.

The 14 plates of the day & night living *Cerachneis immutatus* (53) are indeed not as ~~high~~ high as broad.

It is paleontologically possible to reconstruct the form of a fossil eye from ~~the~~ a single plate, but it is not possible to determine whether it was diurnal or nocturnal. Only that the eyes of a raptor are fixed by long, narrow plates; and an extremely light structure is an attribute confined to the owl.

From Tilly Edinger

über Knochen Scleralringe

The 15 plates of Aptenodytes patagonica
(48) are very regularly arranged: 2
entirely on the surface lying against each other
with

that the tendency of all eyes to roundness
can be so successfully ^{overcome} in the oval eye,

Sauvignat explains (1909) by their inflexibility

Nyctea has 17 plates, Symnium 15

area, 123 mm wide extends out from left
 carpus to carpus + contains impression of at
 least 10 feathers the longest of which is 218 mm ^{the shortest 178 mm}
 on the opposite side of the carpus ~~appear~~ are
 seemingly the ^{impressions of} rachises of 13 feathers

Extending from the main slab to the small piece is
 a fragment of bone ^(230 mm long x 38 mm broad) resembling a flattened limb
 bone about as broad as the humerus to which it is
 adjacent. It tapers at one end and suggests the
 tapered tip of a scapula but is excessive large
 for this element. Possibly it is a fragment of humerus

111 mm from proximal edge of humerus is a
 diagonal scar 13 mm from palmar edge
 on ext. surface (5 mm across at broadest before
 it breaks off. Could be scar at prox end?)

$$\begin{array}{r} 230 \\ 593 \\ \hline 823 \end{array}$$

$$823 \overline{) 6490}$$

$$\begin{array}{r} 12 \\ 649 \overline{) 823} \\ 649 \\ \hline 1740 \\ 1298 \\ \hline 442 \end{array}$$

$$\begin{array}{r} 357 \\ 137.5 \\ 51 \\ 298 \\ \hline 843 \end{array}$$

$$\begin{array}{r} 12 \quad 2.54 \\ 25 \quad 508 \\ \hline 259 \\ 20 \times 6 \end{array}$$

$$843 : 204.8 = 1565 : X$$

$$\begin{array}{r} 39370 \\ 400 \\ \hline 157480 \end{array}$$

$$\begin{array}{r} 204.8 \\ 1565 \\ \hline 10240 \\ 12288 \\ \hline 10240 \\ 2048 \\ 3205120 \quad (380) \\ 2529 \\ \hline 6761 \\ 6744 \\ \hline 171 \end{array}$$

$$\begin{array}{r} 404 \\ 350 \\ \hline 54 \end{array}$$

$$\begin{array}{r} 39370 \\ 395 \\ \hline 196850 \\ 354330 \\ \hline 178110 \\ 15651150 \end{array}$$

$$77'' : 20 = 96 : X$$

$$77 \overline{) 1920} (25$$

$$\begin{array}{r} 154 \\ 380 \\ 380 \\ 514 \end{array}$$

$$120 : 24 : 96 : X \cdot 19.2$$

$$120 \overline{) 240} \cdot 2$$

$$84 \overline{) 230} \cdot 2.73$$

$$\begin{array}{r} 168 \\ 620 \\ 588 \\ 320 \end{array}$$

$$84 \overline{) 200} \cdot 2.38$$

$$\begin{array}{r} 168 \\ 320 \\ 252 \\ 680 \end{array}$$

$$77 \overline{) 200} \cdot 2.6$$

$$\begin{array}{r} 154 \\ 460 \\ 306 \\ 690 \\ 306 \\ 384 \\ 60 \\ 275590 \\ 178 \\ 89370 \end{array}$$

$$77 \overline{) 593} \cdot 7.7$$

$$\begin{array}{r} 593 \\ 519 \\ 74 \\ 800 \\ 550 \\ 250 \\ 1032 \\ 800 \\ 2580 \\ 650 \\ 916 \end{array}$$

$$52133750$$

$$\begin{array}{r} 4125 \\ 12375 \\ 4125 \\ 96250 \\ 39370 \\ 1375 \\ 8115 \\ 24345 \\ 8115 \\ 189350 \\ 39370 \\ 240.5 \end{array}$$

$$18 \frac{1}{2} - 20$$

$$\begin{array}{r} 194 \\ 4 \\ 51 \\ 13 \frac{3}{4} \\ 1.22 \end{array}$$

$$120 \overline{) 240} \cdot 2$$

$$\begin{array}{r} 39370 \\ 139 \\ 34330 \\ 11811 \\ 39370 \\ 54724.5 \end{array}$$

$$21$$

$$\begin{array}{r} 24 \\ 21 \\ 3 \\ 5.1 \\ 15.1 \\ 1 \end{array}$$

OSTEODONTORNIS
HABITS AND APPEARANCE OF ODONTORAMPHORNIS

Lambrecht (1930, p. 16) postulated that Pseudodontornis was a good flier, perhaps similar to the Pelican. This opinion he based on the pneumaticity observed in the skull and also on the presence of a large sclerotic ring. In the latter regard he refers (p. 17) to Dabelow who has shown that large sclerotic rings occur in birds that are strong fliers. Were it not for the sclerotic ring and the pneumaticity of the skull, ~~xxx~~ Lambrecht states, one might assume from the large, toothed rostrum that the bird was flightless. The specimen of ~~Odontoramphornis~~ ^{osteodontornis} now affords proof that the pseudontornithids were fliers ^{do} and good fliers, their flight probably resembling [^] that sailing, effortless flight of the ~~Rail~~ albatrosses more closely than that of the Pelican. ~~on~~

wing spread
One would be inclined to believe that these birds were not divers.

The very large size with extremely long wing bones would suggest that like the albatross and frigate bird, they ^{winged over water and fed upon fish} stayed ~~on the surface of the~~ ^{even} water. ^{that could be snatched near the surface} The short tarseled, long-toed feet, lacking a hind toe also suggest lessened diving and swimming ability. The only contradiction to these suggestions is the evidence offered by Lambrecht (footnote, p. 17) derived in turn from Ischreyt's Comparative Anatomy of the Eyes of Ducks, that the sclerotic ring is especially well developed in divers. This is a point on which I have been unable to gain any personal information or experience.

The toothed jaws suggest that the bird captured live fish of fairly large size. This in turn would suggest that it was capable of diving. Lambrecht ^{thought} also postulated that Pseudodontornis may have been a diver, ^{mentions in this} based on ^(Comp. anat. of Duck eyes)

regard also
The work of Ischreyt who believed that the sclerotic ring was espec. well developed in the diving birds. [^] ~~He~~ The albatrosses ^{to} the frigate ~~birds~~ ^{from these} ~~birds~~ are surface feeders, as are the white Pelicans, Pel. a however is a diver.

647

252

500 +

1399

70

1469

0.39370

140

80

0.39370

140

1574800

393700

55.118000

25.4 mm = 2.54 cm

25 mm = 2.5 cm

139.9 mm = 139.9 mm

140 cm =

24

84

96

192
2016

120 : 24 : 84 : 20

2016 = 2400

12/100 28

120 : 24 = X : 20

24 = 2400

100

100 = 39.3

138.8 mm

= 54"

1 inch = 2.540005 cm

1 cm = .39370 inches

.39370

322

78740

78740

118110

12677140

2.54

12 inch

508

254

30, x .8

39370

1358

314960

314960

118110

39370

54645560

1.20

26

720

240

24) 3120

13

12 : 20 = X : 24

204 = 288

X = 14"

24

12

48

24

130

26 : X = 24 : 120

24 = 3120

26 : X = 20 : 80

20 = 2080

= 104

10

12) 130

100 : 270 = X : 647

270X = 64700

X = 239 mm

66.5 : 124.5 = X = 647

124.5X =

647

665

3235

3882

3882

430255 (345)

3735

5675

4980

4980

6225

239

270) 64700

540

1070

2810

20

213

78740

9409430

39370

23.9 cm

354330

118110

78740

9409430

39370

345

196850

157450

118110

13582650

Of the leg bones only the tarsometatarsus and
 toes can be measured. ^{Relative to the length of ulna or carpus} ~~Proportionately~~ The tarsometatarsus
 in pelicans
 tarsus is shorter than in the albatross, but
 not as short as in the frigate bird. The proximal
 end of the tarsus is ^{incompletely} revealed in a latex cast as
 having a projective calcaneal hypotarsus similar
 to that of the pelican.

Only the three front toes are present. All
 three exceed the tarsometatarsus in length. The
 middle & outer toes are nearly equal with the
 middle possibly exceeding the inner of the outer by
 $\frac{1}{8}$ inch. (Pelican middle & outer about equal, but int. only

to second phal. of median toe	Phal. of median									
	Pelican	Frigate	Phaethon	Sula	Phal. ^{egulus} allatus	Puffin	Puffin	Puffin	Puffin	Puffin
1 int $5\frac{1}{2}$ in	85 mm.	37 mm.	29 mm.	42 mm.	53 mm.	140 mm.	110 mm.	58 mm.	57 mm.	
2 med $5\frac{3}{4}$ in	124	59	34	63	77	180	115	70	67	
3 ext $5\frac{5}{8}$ in	120	45	33	58	92	190	115	70	67	
4 tarsus $4\frac{1}{2}$ in	90	17	20	34	60	125	77	50	55	
ratio 4:1 $82\frac{1}{2}\%$	105%	50%				90	70			
4:1 $282\frac{1}{2}\%$	71	28.8				69	61			

2X Try to find inner toe.

albatrosses & other sea birds eat squid (surface?)
fulmars - ^{mainly} carrion (surface), and then on fish, capelin, etc.
jelly fish, schools of surface fish

Some petrels & shearwaters dive sometimes for food. Swim lightly
in rapid. Dive from the surface, on which
they flash light.

Tropic Bird - usually dives for its food of the marine animals
dives from 50' above surface

Boobies - eat fish smaller caught by diving. Very good divers
from above surface or surface

Gannet may descend in a dive from 50-100'.

Comorant - pursue prey under water (fish) seizes
with hooked beak. Dives by springing upward
from surface. Feet only propel the dive & swimming

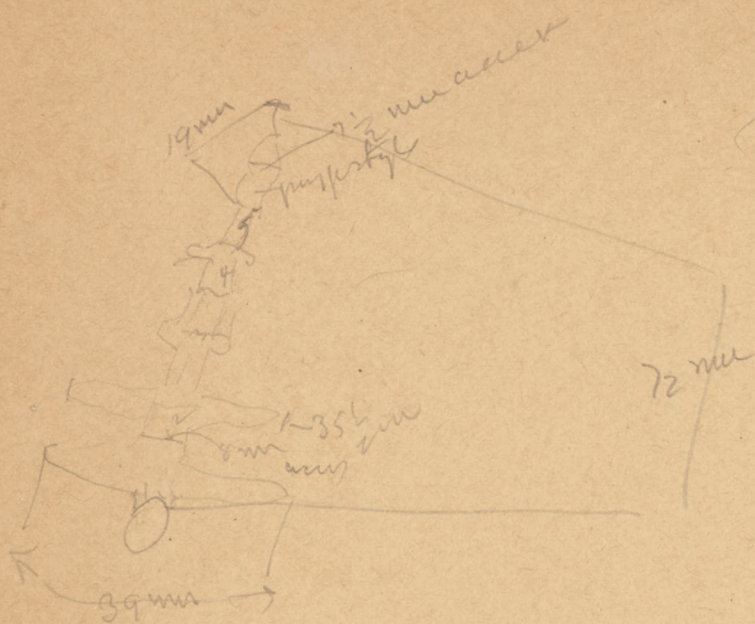
White Pelican - feeds on surface - does not dive
head may submerge. Seems well
built for diving

Brown Pelican - Dive for fish from above surface
(10' - 50' feet above). Also are
scavengers.

Suez - Eat fish ^{from surface} frequently gotten by making
other birds disgorge. Also other
marine animals
Never dives - poor swimmer

5 Caudals

04 + 147



$$\begin{array}{r} 130 \\ 20 \\ \hline 150 \\ 150 \\ \hline 300 \end{array}$$

Extra

$$\begin{array}{r} 34.5 : 5.5 : 5 : 1.6 \\ 345 \overline{) 555} \\ \underline{345} \\ 2100 \\ \underline{2070} \\ 300 \end{array}$$

15 'teeth' or spines above, 17 below?

Primary # 2 (?) $15\frac{1}{2}$ - $16\frac{1}{2}$ inches (?), attached to tip of 1st phalanx of digit 2

allow for the characteristic proximal contours, and at the same time would provide a length, relative to that of the ulna, proportionately the same as in Diomedea. This addition to humeral length would raise the measurement of wing extent to 14 feet 2 inches.

If, as suggested above, the measurable feathers do not represent the longest primaries of Osteodontornis, a still greater wing extent would be expected. In Diomedea and Pelecanus the ulna is approximately 60-63 per cent of the length of the pinion (measured from the carpal joint to the tip of the longest primary). If the same was true of Osteodontornis, the pinion would have been approximately 40 inches long and the total extent from wingtip to wingtip across the body, over 16 feet. See table below for estimated measurements.

Measurements and/or Estimates of Length of Wing Bones and
and Feathers in Osteodontornis

	Actual Measurements	Actual Meas- urements except estimated Humerus	Humeral and Pinion Lengths estimated
④ Length ulna	25½ inches	25½ inches	25½ inches
Length carpometacarpus	10	10	10
① Length Humerus	23½	26½	26½
③ Length Pinion			40
Length Phl, D1	22-3/4	2-3/4	
" Longest feather	15-3/4	15-3/4	
Length one wingt of wings	6ft. 5½ in.	6ft. 8½ in	7 ft. 8 in.
Estimated wing-spread	13ft. 8 in.	14 ft. 2 in.	16 ft. 1 in.

Characters of *Odontopteryx*, *Pseudodontomys*, & *Sp. nov.* Fossil (= *Osteodontomys*)

Character	<i>Odontopteryx</i>	<i>Pseudodontomys</i>	New fossil = <i>O. one</i> ^{not named}
Supraorbital fossae	Absent	Absent	Absent
Frontals Posteriorly	Broad - smooth. Not temporal fossae medially convex from side to side.	Broad & smooth. Temporal fossae slight if any.	Broad - Presumably temporal fossae doubtful.
Over orbit	Very narrow 24% of post-br. slightly concave 26%.	Narrow - 30% (approx) of post-br. concave here.	Narrow 31% (very approx) of post-br. appear concave here.
Ratio br. over orbit to breadth at suture	66% 12 suborb. 18 sut.	69%?	22 and 28 = 35? 60 = 77%?
Supraorbital fossae	None	None	None
Lacrimal	Slant slightly posterior	Perpendicular	Perpendicular
Post to orbits	Bounded by a hind wall but no process	Bounded by a hind wall no process	Apparently bounded by hind wall process gone & even more likely
Rostrum (Upper) at suture dorsal edge	Flattened posteriorly but bordered by 2 obtuse "ridges" which as they go forward to form the median convex ridge 11mm ant. to ant. edge of orbit ratio this dist. to interorbital br. 90% Suture straight	Depressed dorsally - posteriorly. Slender dorsal side concave? 2	Flattened or depressed. Due to curvature?
Position of suture	20mm ant. to ant. edge of orbit Ratio to interorbital br. 100+% Suture straight	20mm ant. to ant. edge of orbit Ratio to interorbital br. 100+% Suture straight	12-14mm ant. to ant. edge of orbit ratio to interorbital br. 64% Suture slightly
Groove	Ascends from preorbital notch then straightens	Ascends from preorbital notch then straightens & proceeds forward parallel to upper edge	Ascends from preorbital notch then proceeds forward parallel to upper edge runs off at apex in a shallow lower edge rectifying groove extends a bit above. Small but not insignificant. At spot where groove ceases to ascend. 90mm from suture 105+ in front of orbit
External nares	Uncertain if present. If notch is nares it is above the groove & ant. to the spot where the groove ceases to ascend 24mm in front of suture 35.9 in front of orbit.	On the groove, very narrow, long. at spot where groove ceases to ascend 90mm from suture 110 in front of orbit	On the groove, very narrow, long. at spot where groove ceases to ascend. 90mm from suture 105+ in front of orbit
Ht. rel. to br. below suture	Ht 20, br 25 = 80% 20 at suture 18 = 111+	Ht 39.6 br at suture 26.1 = 149%	37 1/2 ht br at suture 28-35? 130% - 107%
Position preorbital notch	Directly below suture & not very deep. rostrum ascends almost vertically from it	Slightly forward of suture. More deeply notched than in <i>Od.</i> & rostrum ascends up & slopes backward from it.	Almost directly under suture sort of double. Converge one for zygoma slightly forward of the latter. Rostrum ascends almost vertically from the upper.
Zygoma	Long & slender	Slender & very broad	Short but not so broad as <i>Pseud.</i> , broader than <i>Od.</i>

Palatal area	not defined	very large (bit angle 40mm. extend but by beyond nares level	Slows 2 below vomer extend 50mm forward from not but not to nares level
lower jaw suture at dentary	slopes just behind from ^{tooth} edge upper end on level with preorbital notch	Nearly vertical but has a jagged forward bend in middle upper end 30 or more mm in front of preorbital notch	Nearly vertical but has jagged forward bend below last tooth, upper end 30 or more mm in front of preorbital notch
Longitudinal groove	Groove is not longitudinal but runs downwards rather abruptly from the suture	Longitudinal groove slows parallel to ventral edge on a much of lower jaw as is present	Appears to be a longit group parallel to vent edge in part but as jaw widens line seems to lay straight & edges of jaw slope away from it so it is farther from edge
Depth	Deepest below lacinnal but has no coronoid process	Deepest anterior to lacinnal appears to come to a process like point of depth about 53.3? mm Depth at suture 43.4	Deepest ant. to lacinnal coronoid process but deeper part. Depth about 54 mm Depth at suture 49.8
Articular end	Post. tip missing	Post. end slows as sloping downward & forward slightly from facet with quadrate	Extends further past facet beyond facet with quadrate & does <u>not</u> slope forward (back if anything - or straight)
Teeth	Slope forward; 8 above (2 large) and 7 below (3 large) in about $\frac{1}{3}$ of total length	Vertical. 6 above? 5 below	Vertical 18 below (5 large) 17 above - & not all there (5 large)

Pseudodontonius

Teeth on both max premax
(how can he say this -
premax not present?)

- ① Post most tooth 15 mm
ant to preorbit, notch
(may be another yet
to find back of this)
this tooth is 15 mm
long at base &
17 mm high (lay out
upper tooth)

(65 mm ant
to notch in
Odontaspis)

- ② 50 mm ant, tooth 14 mm long
by 10 mm high with
tiny toothlet in front of it
- ③ 25 mm ant (to toothlet?)
or tooth?
tooth 12 long x 13 high
also with small one
before it,
all teeth $\perp$ to foramen

Lower teeth ① Post. most 45 from
preorbit, notch
about 14 ~~from~~ from next tooth

- ② next also 14 mm
from the next

- ③ 3rd from post is
largest

as in upper jaw,
small teeth bear,
but are not near
the large teeth but
in the middle
between each 2.

Odontaspis

little but
more of them

- ① 5 ant 10
2 max teeth, 2
large ($\frac{1}{2}$ between) the
rest small or minute.
compressed triangular
pointed ^{ant} $\frac{1}{2}$ in of foramen
1st one almost below the
frontal notch

Teeth on surface show
feebly 1 linear + frontal
indentations relating to vascular
system attachment of bony
to bony beak.

Teeth slant forward.

5 from post. is largest

Total of 26 (of which 10 large)
est'd for lower jaw.

P

Occiput slopes steeply

Quadrato

Occ. condyle

Zygoma

Occiput

parietal

depth occiput 25 mm to foramen
br. 32 mm
slopes less steeply than
broader than high
cerebellum swells to overhang
the foramen. Med ridge
on cerebellar prom.
(br 6 mm, length 20) no. 15 to
zygoma fact
one

slender, straight
styliform br. $4\frac{1}{2}$ mm
probable length 48.5 mm.
as meas on illus by H

smoothly transversely
dashed; feebly
impressed by temporal
fossa.

br. cranium at temp fossa
45 mm.
length from lat occipital ridge
to hind margin of orbit 16 mm
length frontals 50 mm
br. in orbitals, 12 mm
fronto nasal suture br. 20 mm
ant-post diam of orbit 30 mm
vert " " 27 mm
(Oral with small end forward)

Birds which have tooth patches (from Owen on Odontopteryx)

sheath only {
Falco - 1 on upper jaw
Larus " " "
♂ of Linytus Andriodon
Didunculus (Samoa) has nodules leaving

3 horny processes in
sheath of lower mandible
hook-like projection of up mand.

transversely set laminae in
Antidors o Phacinopterus
ptd in Merganser

Hardness salts in excess give sheath ivory char in I-b. woodpecker
Hooded Lizard closest approach to Odontopteryx Chlamydosaurus
but dentary
not seen in Odontopteryx

P

~~Systematic Position~~

Odonopteryx

upper surface
rostrum

$$\begin{array}{r} 22 \overline{) 140} \\ 132 \\ \hline 80 \end{array}$$

~~arch~~
median raised
area 1st flat
then convex as
it narrows anteriorly

No notch at front
nasal suture for
nasal process of
premax
suture abrupt
as in *Pelecaniformes*
(mention *Sula*)
[note this is not the
case in *Frigate*]

Frontal very constricted
above orbit (more than
in *Pelecaniformes*)

40

height rostrum at base
20 mm

trans. diam at base
at level of fronto nasal
suture = 25 mm

total skull length
estd at 5-6 inches

56

~~Facet for~~ *Stigma*. extends
beyond outer edge of quadrats

same

Not disarmed

35.9 before roots) questioned
by Spulzpi
Apr 24 " setting of this are new
(certainly not
ausseifone)

longitud groove ~~as in~~
~~sculpture~~ ~~that~~, begins below
zygoma runs in convex
curve upward to and fr
vertically $\frac{1}{4}$ rostrum, then
proceeds straight

P

Coronoid border.

convex but not ^{identifying} ^{proceeded}
as a crowned process ○

No trace of raised
coronoid border or
of alveolus of a distinct
process (such as in *Mergus*)
lacking process or raised
border as in *Pelecanus*
Resembles *auxifrons*
in thickness & depth (high)
in coronoid area
more than *Pelecanus* which
are thicker & shallower

Vert. diam of articulation
at joint with quadrate
shown by impression in
matrix = 9 mm., increases
to 12 mm. below ant border
of orbit.
ht of dentary where
it is broken 10 mm.

Foramen swells where it
forms base of the
conical tooth

Pseudodontornis
 Lower jaw Articular, angular
 & supraangular, dentary
 strongly built &
 well ossified so
 that the sutures
 cannot be discerned

[Lambrecht does not
 interpret the break
 ant. to the coronoid
 as a suture but
 it occurs the same
 in ovi]

No mandibular foramen

Parallel ^{longitudinal} grooves in lower
 beak. Lambrecht says
 these are present also in
 Cygnus, ^{Anas} ~~Anas~~ ^{other Anseres}
 Somateria, Gus
 Phoenicopterus

Temporal fossa

Supraorbital groove

Short

Odontopteryx

suture slopes downward
 & posterior

Parallel grooves present
 begins near ^{suture} supraangular
 curves down & forward
 as in Cygnus superciliaris

short

absent
 (as in Pelicaniformes
 & Anseriformes)

Banded by hind wall
 (not found in Pelicaniformes)
 but ok in Anseriformes
 altho the latter has a prominent
 forward process which
 Odontopteryx does not have,
 upper border thin &
 sharp

Lower jaw fragments 2707A
Upper jaw fragment 2707B
Cranial fragments (?) 2707C
Atlas (1) 2707D
rib or ? (1) 2707E
Misc. 2707

Osteodontornis referred

LACM 2707

San Fernando Valley

Fossil rib - 92.0 - 101.6 mm. moir's sternal rib #3? 41.9

Atlas ant, ant, br. 15.2

7.0

q. post. br. 12.8

8.1

ht of "U" 9.5

3.3

Space bet. RTL
not to q post. fac 9.5

4.7 Diomedea Pelican 4.1

Dorsovent depth
post. facet 4.4

2.5 Diomedea 3.5 Pelican 3.5

6
176) 1060
1056

Length zygonia D. exulans 84.6

O. nigripes 520

Pelican 76-83

Photomicrograph of a
Fig. __ This section through a "tooth" in Osteodontornis porri.

- A. Haversian canals; B. circumferential lamellae; C. Volkmann canal; D. matrix; E. material for affixing specimen to slide (thermo plastic cement).

A SECOND RECORD OF OSTEODONTORNIS,
MIOCENE "TOOTHED" BIRD

By

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Through the generosity of Michael Bell, Junior High School student of Sherman Oaks, California, the Los Angeles County Museum has recently acquired a collection of fossils from Upper Miocene diatomaceous shales on the north slope of the Santa Monica Mountains in the San Fernando Valley, Los Angeles County. Bell collected the fossils in an extensive freeway cut at the end of Del Gado Drive (see fig. 1) near the intersection of Sepulveda and Ventura Blvds., Sherman Oaks. Most of the specimens are fish, but included as well are three specimens of birds: a shearwater, a sulid, and the species here to be discussed. The fish are being studied by Jules Crane, and a report on these may be expected in the future.

The photograph of the locality (fig. 1) was taken by Ed Mercurio, High School student of Sherman Oaks. All other photographs were made by George Brauer, Los Angeles County Museum photographer.

Among the specimens that had been set aside with the fish, were several fragments of jaw bone, the teeth of which, though superficially fishlike, suggested to us the bony serrations of the jaws of the marine bird, Osteodontornis orri Howard (1957). One

"tooth" was removed for sectioning, and under microscopic examination, clearly showed the Haversian system characteristic of bone, as in the "teeth" of Osteodontornis. Meanwhile the various jaw fragments were assembled and pieced together, revealing a long, slender mandible as in Osteodontornis. Although the material here available is very scanty as compared with the excellently preserved type specimen of O. orri at the Santa Barbara Museum of Natural History, we are confident that it represents the same species.

From the many southern California sites of Miocene fossiliferous shales, this is only the second record of Osteodontornis. As this genus differs markedly from any bird living today, it is important to report in detail the characteristics of this specimen.

Material Available

As explained by the donor, the chunk of diatomaceous shale in which this specimen was found had fallen from the cliff above. The shale had split longitudinally along the cleavage plane, and had also broken up into small pieces. Seven or eight fragments represent parts of lower mandible, one of which has a small patch of outer bone surface still in tact and appears to be of the left side. ^(fig. 3) The other fragments, which fit together roughly, may represent the right ramus; they are fractured longitudinally so that only the interior structure of the bone is exposed.

A single fragment, approximately 128 mm. long, represents the anterior part of the upper mandible. ^(fig. 2) This is crushed in such a way that three "teeth" of ^{one} ~~the~~ left side appear above and anterior to those of the ^{other} right side. The anteriormost large "tooth" was present on both

right and left sides, one above the other. One of this pair was removed for sectioning and microscopic examination.

Two fragments of the cranial part of the skull are recognizable, but are badly crushed and distorted. The lower half of the atlas is present, with surfaces for articulation with the occipital condyle and axis intact. One other fragment should be recorded although it may not be avian. This is a long, slender bone, apparently complete at one end, broken at the other; if avian it may possibly represent one of the hyoid bones, or a sternal rib.

Description of Material

Lower ^{Mandible} Jaw

By arranging the mandibular fragments together an extent of approximately 262 mm. can be studied, with at least another 115 - 116 mm. represented by crushed bone posterior to the mandibular suture. This posterior portion of the mandible is crushed and split so that it cannot be exactly fitted into place; the position of the suture is, therefore, not clear. It appears, however, to cover a broad area as in the type of Osteodontornis orri. Anterior to the suture the general contour of the ramus and the arrangement of the "teeth" is in close agreement with the corresponding part of the mandible of the type of O. orri. Measurements taken suggest that the lower jaw in the second specimen may be slightly longer, and deeper dorsoventrally, than in the type. The condition of the specimen, however, makes all measurements very uncertain.

It is not possible to determine whether or not the longitudinal sulcus, characteristic of O. orri, was present. Only the interior bony structure of the jaw is exposed in the area where the sulcus should be. There are, however, two longitudinal raised lines on

one section of the mandible, either of which might have formed a depressed sulcus on the outer surface. One of these is about centrally placed dorsoventrally, the other is about 7 mm. from the ventral edge, in approximately the same position as is the sulcus in the type specimen.

Upper ^{Mandible} Jaw

The anterior end of the available premaxillary fragment curves downwards anteriorly, the curvature being like that seen in the type of O. orri. Microscopic examination of the anteriormost surface shows it to be smooth, with external perforations such as characterize the outer surface of avian jaws beneath the horny beak. Doubtless, therefore, the outer contour of the beak is represented here. The terminal tip is missing, as it was in the type, but the anteriormost large tooth is better preserved than in the type, and a smaller tooth is present in front of it in the region which, in the type, was crushed and overlain by one of the wing bones. The length of the premaxilla from the center of the anteriormost large "tooth" to the center of the third large "tooth" (proceeding posteriorly) appears to be roughly 53.5 mm.; in the type this distance is approximately 56 mm. The height of the premaxilla just posterior to the third tooth appears to be approximately 32 mm. in both specimens. Both height and length measurements in the present specimen, are, however, necessarily tentative because of the crushing of the bone.

There is a faint suggestion of a line above the "tooth row", which may represent the location of the longitudinal sulcus noted in the type.

"Teeth"

The "teeth" are essentially as those in Osteodontornis orri (Howard, 1957:10-12). The Haversian canals, lacunae, circumferential lamellae, and Volkmann canals are clearly visible under low power magnification (fig. 4) while under high power magnification the canaliculi and their characteristic relationship to the lacunae are as distinct as in a thin section of a recent bone.

Examination of the jaw bones and a number of the serrations under a dissection microscope reveals that the "teeth" are hollow with bony trabeculae crossing the space within as in O. orri (loc. cit.). The Haversian systems of the jaw bone extend into the "teeth", thus indicating the "teeth" to be processes of the jaws and not true vertebrate teeth. Neither enamel, dentine, nor cementum is present.

One of the distinguishing characters between Osteodontornis and Pseudodontornis (see Howard, 1957:3) is the pattern of the jaw projections. In the latter genus only one small "tooth" occurs between the large projections; in Osteodontornis, there are several. The Sherman Oaks specimen agrees with Osteodontornis; in fact, the general arrangement of the "teeth" is remarkably the same as in the type of O. orri.

The distance between the anteriormost large "tooth" on the premaxilla (hereafter to be referred to as "Upper A") and the third large upper "tooth", proceeding posteriorly (Upper C) varies only 2.5 mm. in the two specimens. Upper A is approximately 7 mm. across the base and 13 mm. high; this "tooth" is incomplete in the type and was not measured. The second large "tooth" (Upper B) is the same height in both specimens -- 12 mm., but seems slightly broader at the base in the type; the ^{basal} area is crushed in the present specimen and cannot be precisely measured. The following description of the

arrangement of the "teeth" from Upper A to Upper C in the Sherman Oaks specimen is duplicated in the type: approximately centered between Upper A and Upper B, a small "tooth" is flanked both anteriorly and posteriorly by a tiny spine; a similar arrangement occurs between Upper B and Upper C, except that the small "tooth" is slightly posterior of the center; Upper C is not nearly so large as Upper B.

In the lower jaw the three large "teeth" (Lowers A, B. and C, proceeding posteriorly) correspond in general size and spacing to the three large teeth in the type jaw. Lower C is the broadest in both specimens (approximately 10 mm.) Lower A measures 8.5 mm. across the base and has a height of 14.2 mm.; this "tooth" was broken at the tip in the type and no measurement is available. Lower B is incomplete in both specimens but gives evidence of being as large or larger than Lower A. Centered between Lower A and Lower B is a small "tooth" with somewhat smaller "teeth" flanking it, one anteriorly, one posteriorly. ^(see fig. 3) These flanking teeth are larger than the "spines" noted in the upper jaw, but between each of these lower teeth there are narrow spinelike ridges. Except for these ridges, size and arrangement of the teeth between Lower A and Lower B was the same in the type of O. orri. If these ridges had been present in the type, they were not preserved. The ^{left} ~~right~~ ramus of the type bore a similar arrangement of three small "teeth" between Lower A and Lower C. On the right ramus of the type, and in the Sherman Oaks specimen, only one "tooth" is preserved between Lower B and Lower C; this is small and slightly posterior of being centered between the large "teeth." In both specimens the flanking "teeth" may have been present in life but lost during the fracturing of the specimen.

Approximately 16 mm. posterior to Lower C is a medium-sized "tooth", 4.8 mm. at base and 7.0 mm. high^h, followed (at a distance of 11.3 mm.) by another slightly heavier "tooth" measuring 5.6 mm. at the base but broken at the tip so the height cannot be measured. These two "teeth" are seemingly slightly different in the type of O. orri, the former smaller, the latter larger.

Atlas

(fig. 5)

The fragment of atlas, incomplete as it is, is the first skeletal element of Osteodontornis in which the articular surfaces can be clearly exposed for study. It merits the following detailed description: anteriorly, surface for articulation with occipital condyle deeply concave, somewhat pear-shaped in outer contour with greatest breadth above the center of the facet; orifice for odontoid process of axis roofed with bony bridge, forming flat dorsal contour to articular surface; posteriorly, ~~surface for~~ articulation with axis ^{narrow and} deeply U-shaped, and markedly convex on lower edge; hypophysis broken, but area of attachment below centrum broad and separated from posterior articular surface by deep indentation; neuropophyses continuing almost directly upwards from upper edge of posterior articular surface, with very slight demarcation between end of facet and beginning of neuropophyses; surface for odontoid process of axis deep anteroposteriorly and dorsoventrally, and relatively narrow from side to side. The strong, bony dorsal bridge, the deep narrow area for the odontoid process, the character of the posterior articular surface and its relationship to the underlying hypophysis all indicate a rigidity and strength of the neck equal to the task of supporting the very heavy skull.

Compared with this element in the Pelecaniformes and the Procellariiformes, the fossil atlas shows greater similarity with the former group. There is considerable variation within each order, and the exact characters of the fossil are not duplicated in either; closest approach is to the genus Morus of the Sulidae in the shape and convexity of the posterior articular surface. In general the following characters distinguish the pelecaniform atlas from that of the procellariiforms: shape of posterior articular surface frequently V- or U-shaped (never this shape in the Procellariiformes examined); area for odontoid process usually deep (though frequently broad rather than narrow), the area shallow in the procellariiforms; neuropophyses generally straighter in pelecaniforms, more laterally extended in procellariiforms, in both groups, however, the articular surface is more clearly set apart from the neuropophyses than is the case in Osteodontornis; odontoid notch bridged with bone in several pelecaniforms (though not in Pelecanus or Fregata), while a cartilaginous bridge occurs in some procellariiforms. This bony bridge, when present, in the pelecaniforms, forms a convex dorsal contour to the articular surface, not straight as in Osteodontornis. Osteodontornis differs from all other species examined in much greater over all size of the atlas; also the dorsoventral depth of the U-shape of the posterior articulation is relatively greater and the centrum is relatively deeper (anteroposteriorly); see Table I.

Other Fragments

The cranial part of the skull is so badly crushed and distorted that an attempt at description or measurement would only result in misinformation. It does suggest, however, the same shortness of the cranial area noted in the type specimen of O. orri.

Table I

Measurements of Atlas (in millimeters)

	<u>Osteodontornis</u> <u>orri</u>	<u>Pelecanus</u> <u>erythrorhynchos</u>	<u>Morus</u> <u>bassana</u>	<u>Diomedea</u> <u>exulans</u>
Greatest breadth centrum (post'ly)	17.6	9.1	8.2	10.8
Greatest depth centrum (antero- posteriorly)	8.9	4.1	3.9	3.8
Greatest dorso- ventral dimension of posterior articulation*	10.6	4.5	4.6	4.4
Dorsoventral dimension of posterior articu- lation at midpoint*	4.4	3.5	2.5	3.5
Breadth between right and left sides of U-shaped posterior articulation	9.5	2.2	4.7	not U-shaped
Greatest breadth anterior articu- lar surface	15.5	7.8	7.5	9.2
Greatest height (dorsoventrally) of anterior articu- lar surface	14.5	6.4	7.0	7.2
Ratio of depth to breadth of centrum (in per cent)	50.6	45.1	47.6	35.2
Ratio height (dorso- ventrally) of post- erior articulation to breadth centrum (in per cent)	60.1	49.5	56.1	40.6
Ratio height to breadth of anterior articulation (in per cent)	93.6	82.0	93.5	78.3

*In Osteodontornis and Morus the greatest dorsoventral dimension of the posterior articulation is considerably greater than the dimension at the midpoint owing to the narrowness of the surface and the U-shape of the articulation. In Pelecanus the surface is relatively broader with a central notch. In Diomedea the surface is practically the same laterally and midpoint

A slender and slightly curved element, with the contour of one end apparently intact, the other end broken, measures 92.5 mm. in length; another 9 mm. ^{was} ~~is~~ represented by impression in the matrix indicating a total length of more than 101.5 mm. for the complete element. A longitudinal groove runs nearly the full length of the concave side of the curve of the bone. In cross section at the broken end the bone is solid and measures 2.2 mm. in diameter. Although this bone was associated with the Osteodontornis specimen, it may as well be fish as bird. Neither ^{Jules} ~~Jack~~ Crane, who is studying the fish, nor the present writers are able positively to identify the element. It is mentioned here for future reference, in the event a similar association may recur.

Summary and Conclusions

A second specimen of Osteodontornis orri, representing the fourth record of the extinct odontopterygiform birds, was recently found in Miocene deposits in the San Fernando Valley, Los Angeles County, California. Although very fragmentary as compared with the type of O. orri, this specimen contributes significant information concerning constancy of "tooth" pattern, and the relationships of this fossil bird. It is now possible to say with some degree of assurance that the pattern of the jaw serrations is an apparently stable characteristic of Osteodontornis. The spacing of the "teeth" and the actual, as well as relative sizes of the projections show remarkably little difference in the two available specimens of O. orri. It was previously suggested (Howard, 1957:12) that the spinelike quality of the smallest upper teeth in the type might not be typical of these projections, but merely the result of the angle of

fracturing. The same spinelike condition prevailing in this second specimen indicates that this represents a normal characteristic of the species.

The atlas fragment, free from matrix, affords the first opportunity to examine in detail the articular surfaces of any element of the skeleton of O. orri. The atlas is an element that might be expected to retain the basic characters of the Order with less adaptive influence than rostrum or limbs. That the fossil atlas displays certain pelecaniform characters adds weight to Wetmore's (1960:8-9) contention (based on a review of the type of the Eocene Odontopteryx) that the odontopterygiform birds should be treated subordinally within the Order Pelecaniformes and not given ordinal status as recommended by the present senior author (Howard, 1957).

Literature Cited

Howard, Hildegard

1957. A gigantic "toothed" marine bird from the Miocene of California. Santa Barbara Mus. Nat. Hist., Bull. 1, Dept. Geol., pp. 1-23, 8 figs. in text.

Wetmore, Alexander

1960. A classification for the birds of the world. Smithsonian Misc. Coll. 139 (11):3-37.

Captions for figures

Fig. 1. Miocene deposits in freeway cut in Sherman Oaks, California from which fossil birds and fish were recovered. Fragment of shale containing specimen referred to Osteodontornis orri Howard was found on road at foot of cliff, at far right of photo. White "ring" on surface of cliff near top is area from which other fossils were collected in situ. Note almost vertical dip of strata.

Fig. 2. Fragment of upper mandible (L.A. Co. Mus. no. 2707B) referred to Osteodontornis orri Howard. Natural size.

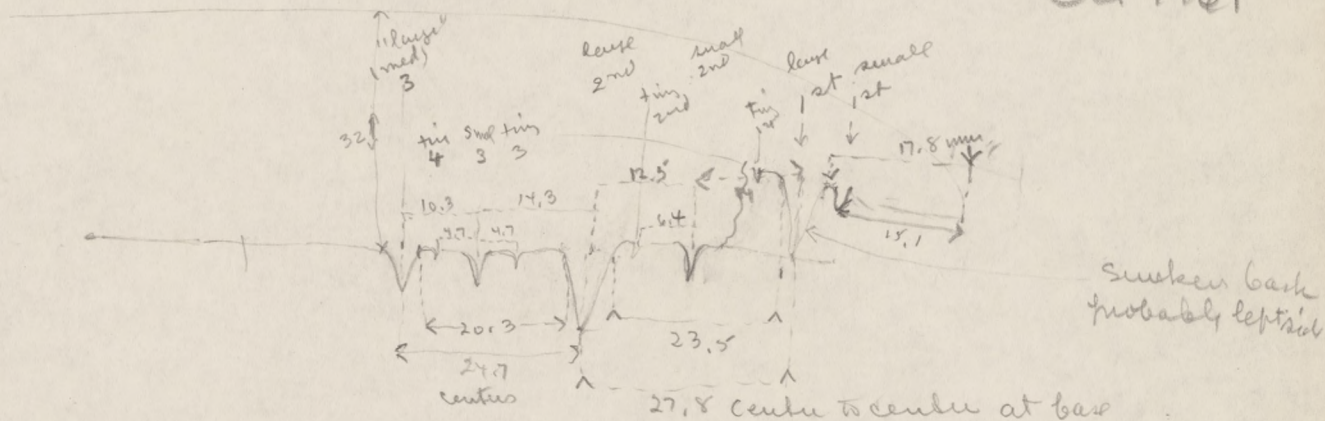
Fig. 3. Fragment of lower mandible (L.A. Co. Mus. no. 2707A) referred ^{to} Osteodontornis orri Howard. Natural size.

Fig. 4. Photomicrograph of a section through a "tooth" removed from upper mandible no. 2707B shown in Fig. 2. Outline below indicates: A. thermoplastic cement used for affixing specimen to slide; B. section of matrix; C. Volkmann canal; D. circumferential lamellae; E. Haversian canals.

Fig. 5. Lower half of atlas (L.A. Co. Mus. no. 2707D) referred to Osteodontornis orri Howard. Left, posterior view; right, anterior view. x 1½.

Tip of up. beak to ant. edge 1st (small) tooth 15.1 mm,
 " " " " 2nd (large) " 17.8 mm
 distance bet. 1st & 2nd large teeth 23.0 mm?
 " from 2nd large anterior to mid side 9.6 mm

L. G. Co. Mus.
 Specimen
 Oct 1961



1 st large	13.6	br base	7.0
2 nd "	13.6	" "	6.5 (?)
3 rd " (med. "	6.5		4.6
1 st small	5.2		
2 nd "	5.2		
3 rd "	4.9		
1			
2			
3 tin	2.5		

fig. upper jaw
 127.7 mm. long. dorsally
 95.2 " " ventrally.
 10 teeth refid (an 11th taken out for sectioning appears to be same for it side as that which remains (left))

② Steodentomus
 from Sherman Oaks

80.8	84.1	101.7
80.8	84.1	73
161.6	168.2	174.4

181.1	81.1	87	106
181.1	81.1	27	73
62.2	62.2	17.4	179

4 Fragments of lower jaw

See Co. Mus.
Specimen
Oct 1944

158

104.3

262.3

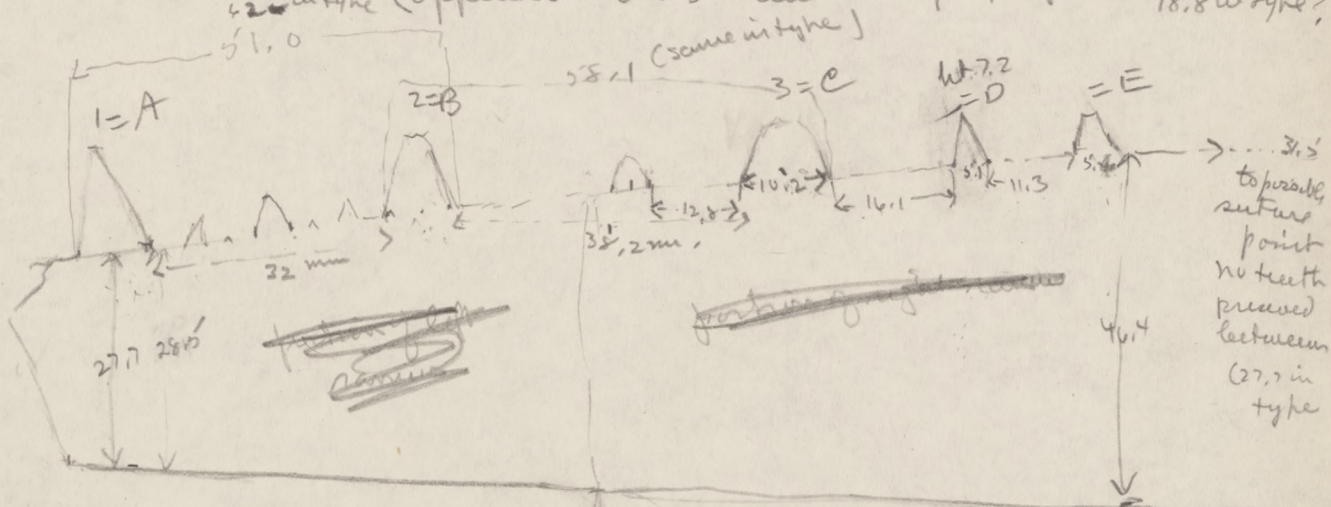
total length of fragments put together

46.4 depth at last tooth on specimen ant to suture

56.8 " " suture? pos. of suture questionable

28.4 " posterior to 1st tooth on specimen ant'ly

22 in type (appears to be 3rd ant to symphysis in type 18.8 in type?)



1st tooth 1 (large) 14.7 mm

br. base " 1 " 8.7

center 1 (large to center 2 large) 41.5

br base 2 (large) 8.8

Dist bet 1 & 2 31.0 mm

ht mid tooth bet 1 & 2 5.4

br " " " 1 & 2 4.3

depth jaw below center # 2 35.9 (25.6 in type)

" " " center # 1 27.7 (24.2 in type)

smaller teeth could undoubtedly occur but 2.5'

total # teeth observable in lower jaw 9 (?)

3 large

1 & 2 with a med, 2 small, 2 fine bet.

2 & 3 " 1 med "

3 has 2 med after it.

in type: 12

1 has med + small in front of it 2

1 & 2 2 med bet 2

2 & 3 " " 2 small bet 3

3 has a med + small post 2

12.7

Osteodermis

May be same bird
cranial part of skull badly crushed 100 mm from sutures to post
tip (unc.)
br. symphyseal nasals to skull 16.9 mm (may really be 16.5)
portion of internal (not) of skull

Small frag. may rep. tip of lower jaw
18.8 mm br.; 9.6 mm. ant-post depth at tip. Very sturdy
with

As the fragments were arranged in place, however,
 The long jaw took shape. ~~The jaw~~ ^{the} ~~author~~ ^{author} ~~removed~~
~~one of the "teeth"~~ from the jaw, ~~sectioned it & subjected~~
^{Brill} ~~it to~~ microscopic examination of one of the "teeth"
 immediately revealed the bony nature of these excrescences,
 and ~~also~~ suggested similarity with the "teeth" of Osteodontobatis,
 More careful examination revealed the following

Although no direct comparison ^{can be made} of overall length of beaks
ⁱⁿ of this specimen ~~with~~ ^{and} that type, ~~that greater depth of~~ ^{means, on the}
 the lower mandible ~~the greater~~ ^{max} ~~of size of teeth~~ suggest
 that this ~~second~~ ^{2nd} specimen slightly exceeded the type
 in size.

	Comp. of size of 2nd spec. and type	
	Type	2nd spec.
Depth of low. mand. from ^{at} suture*	50.0	56.8 *
Depth low mand. post to last mandibular ^{mandibular} sized tooth before suture	40.0	46.4
Distance from last mandibular ^{mandibular} sized ^{sized} to ^{to} mandibular ^{mandibular} suture	27.7	31.5 *
Ap. br. of a lower tooth	10.0	10.2
Ap. br. of a lower tooth	13.0	14.7

* Exact position of suture questionable

A second record of California's "Toothed"
bird, *Osteodontornis*

Michael Bell, Jr. Hi. School 7 No. Hollywood has
Among The many specimens of fossil fish
recently contributed to the L.A. Co. Mus. a number
of fossils ^{which he collected} from the Miocene shales on the west
slopes of the Sta. Monica mts. near Sepulveda &
Ventura Bluffs. Most of the specimens are fish.
But also included are three birds: a shearwater,
^{Howard (1957)} *Puffinus*, a rail, and *Osteodontornis orri*, ^{Ther}

~~gigantic ^{bird} with tooth-like serrations of the~~
~~is characterized by its long beak beaming~~
~~jaw. This latter species is represented by a several~~
~~fragments of the fish (including portions of both upper~~
~~+ lower jaws) and various miscellaneous fragments~~
~~unrecognizable pieces, some of which may also belong~~
~~to the jaws. By careful piecing together, & relating~~
~~of fragments one to another, the character of the lower~~
~~jaw for a distance of 262 mm. and of the upper mandible~~
~~for 127.7 mm. can be discerned.~~

~~the lower jaw is represented by 7 fragments of the~~
~~right ramus extending approximately 262 mm. in~~
~~length, and one smaller, though better preserved fragment~~
~~of the left ramus. A single fragment, 127.7 mm.~~
~~long, represents the ^{ant. part of the} upper jaw. One long slender, ~~which~~~~
~~fragment, at first in this fragmented condition, the identity~~
~~of the specimen, when first brought ^{was} was ~~was~~ not~~
~~immediately recognized, ^{as a jaw} but was ~~and~~ ^{at first with}~~
~~at first ~~was~~ ^{the jaw} ~~was~~ ^{the jaw} ~~was~~ ^{the jaw}~~
~~fish bones ~~was~~ taken by Smith ~~from~~ this deposit. ~~was~~~~

Ceratobranchial (?)

A slender and slightly curved element, ^{broken at one end but} with contour of the proximal (?) tip apparently intact, measures 92.5 mm; another 9 mm. is represented by impression in the matrix. The distal (?) tip is missing. In cross section at the broken end, the bone is solid; the contour ^{here} is broadly U-shaped, and the bone measures 2.2 mm. in diameter at this point. The

U-shaped cross section is reflected on one surface of the bone by a longitudinal groove. In general shape, solid cross section, and longitudinal groove, the bone resembles a ceratobranchial. It is not, however, identical ^{in contour} with any ceratobranchial available for comparison. The bone is considerably longer, also, than this element in *Pelecanus* ~~occidentalis californicus~~ (which measured 53.2 mm.)

In relation to the size of the skull, the ~~same~~ (also columbianus) ceratobranchial is larger (50.6)

in the ~~same~~ *Olor columbianus* and *Diomedea nigripes* (47.8) ~~the three largest specimens in the collection~~ (50.6) ~~7.8 mm. respectively~~.

No specimens of ceratobranchials of *Diomedea exulans* are available ~~for comparison~~ but a study of the skull ~~of the latter form~~ ^{of the latter form} ~~judging from the~~ ^{an examination of the area of the skull} ~~judging from the~~ ^{it appears that this element} ~~that of D. nigripes~~ should be at least 70% larger

than in the latter form *D. nigripes*, or close to 80 mm.

Unfortunately the under side of the skull ~~can not be~~ ^{of the latter form} studied in *Oreodroma*. The ~~length of the~~ ^{length of the}

zygoma suggests ~~that the palatal area is~~ ^{is 0.1} relatively shorter than in *Diomedea*, in which case the element here under consideration seems excessively long.

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Add Geo. Simpson
Hawland
present address

Atlas

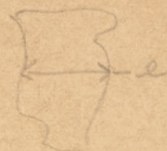
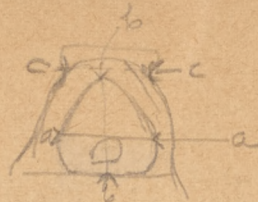
a greatest br of hollow 15 mm.

b " " " 14.4

c br. above hollow 13.1

d br on other side from B-9.5

e depth (ant-post.) 9.9



same meas. in *D. exulans*

a = 9.6

b = 7.7

c = 8.0

d = 5.5

e = 4.0

more Bassano

a = 7.3

b = 7.3

c = 3.5

d = 5.0

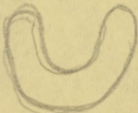
e = 4.1

Atlas

 Pelican

 Ciconia

 mois

 Ascendant.

Atlas in procellarii forms

Puffinus (# 50)

- ① Post'l. facet to art. with axis is small, flat (very slightly convex) ~~or protruding~~ blends in ventrally to area of attach. of projection to go under axis. Not as high as ant. facet edges of bone about lateral beyond the facet at same level partly
- ② Area for odontoid process rel. broad - almost as broad as the facet (described in ①) and not very deep
- ③ Hole is bridged with cartilage.
- ④ Projection to underlie axis is narrow rel. to span of bone but about equal to facet (in ①)
- ⑤ Ant'l. facet for skull broad above, narrow below, wider than high, not very deep

Fulmarus (472) T 27

- ① Similar to Puffinus but broader laterally
- ② Similar " "
- ③ Hole bridged with cartilage in # 27
- ④ Narrower than in Puffinus
- ⑤ Similar to Puffinus in general

Diomedea exulans

- ① Broad art. (laterally) rather flat, ^{greatly} ~~greatly~~ ^{reaches} ~~reaches~~ dorsal edge of ant. facet. Bone continues to go ^{between} ~~between~~ ^{slightly} ~~slightly~~ ^{on} ~~on~~ ^{thru} ~~thru~~
- ② About as in Puffinus (rather broad & shallow)
- ③ No bridge ~~is present~~
- ④ Projection broad where it attaches (as broad as facet of ①)
- ⑤ Broad art. with skull (broader than high). Rounded below (not narrowed as in Puffinus or Fulmarus)

Diomedea nigripes

Same as *D. exulans* except in ⑤ lower edge narrows
to more like Puffinus & Fulmarus

Pelecaniformes atlas cont'd

Phalacrocorax penic. (670)

- ① Postf. - facet flat broad & high, No undercut
Doesn't reach dorsal edge of ant. art. Bone on
sides proceeds up & moderately ant.
- ② Broad deep area for odont. process
- ③ no bridge but hole very restricted
- ④ Broad projectus. Broader than facet ①
- ⑤ Narrow below, broader above; rises above lat. stuts

Sula leucogaster (268) - dactylata (1356)

- ① 1356 rounded (U-shape) 1268 V shape. Both broad
& high with no undercut. Lat. bone rises with
slight outwards extent
- ② narrow deep area for odontoid
- ③ Hole bridged with bone
- ④ Projectus broad in 1356 (may make the U shape)
narrower in 1268
- ⑤ Art. is essentially oval in 1356, a bit more pear-shaped
above in 1268 Dorsal bridge ~~rounds~~ convex in both
area below facet rounded (no keel such as in
Fregata & *Audubon*)

Mareca Cassin's 18173

- ① Very broadly & shallowly U-shaped, convex surface,
same undercut. Sides proceed up & only slightly ant
no much ant.
- ② Deep & broad
- ③ Bridged hole
- ④ Moderately - ~~about width of~~ breadth
- ⑤ Essentially round - convex across bridge
lat. stuts recede postf.

Measurements of Atlas (in millimeters)

Osteodontornis Pelecanus Moris Diomedea
orri erythrorhynchos bassana exulans

①	Greatest breadth centrum (post'ly)	17.6	9.1	8.2	10.8
②	Greatest depth centrum (antero- posteriorly)	8.9	4.1	3.9	3.8
③	^{dorso-ventral dimension} Greatest height posterior articu- lation*	10.6	4.5	4.6	4.4
Insert ↑ ↑ ↑ ↑	Greatest breadth anterior articular surface	15.5	7.8	7.5	9.2
	Greatest height anterior articular surface	14.5	6.4	7.0	7.2
	Ratio of height of posterior surface to breadth centrum (in per cent)	60.1	49.5	56.1	40.6
	Ratio height to breadth of anterior articular surface (in percent)	93.6	82.0	93.5	78.3
	Ratio depth to breadth, centrum (in percent)	50.6	45.1	47.6	35.2
	Breadth between right and left sides of U-shaped posterior articular surface	9.5	2.2	4.7	not U-shaped
④	^{dorso-ventral dimension} Height posterior articular surface at mid-point *	4.4	3.5	2.5	3.5

*Height of posterior articulation in Osteodontornis and Moris is measured from top to bottom of the U-shape formed by the articulation, ~~not the width~~ of the actual surface; in Pelecanus and Diomedea, the measurement is from top to bottom of the surface itself.

In Osteodontornis & Moris the greatest dorso-ventral dimension of the post-artic surface is ^{considerably} greater than the dimension at the mid-point owing to the U-shape of the articulation. The U-shape of the post-artic is reflected in

Narrow surf. forms a U-shape in Osteod & Moris bassana. In Pelican a broader surface is reflected.

surface is ^{higher} than at mid-point. In Diomedea surf. is ^{probably} the same at mid & lateral.

Measurements of Atlas

La Co. Mus. Spec.

Osteodonta

1770

Pelecanus

1873

Moris

230
Diomedea
exulans

va	Gr. br. ant. art. h	15.5	7.8	7.5	9.2
e	Gr. br. " "	14.5	6.4	7.0	7.2
vc	Gr. br. post. ly	12.6	9.1	8.2	10.8
vd	" " post. facet	12.1	8.9	8.1	10.4
ve	Ht post. facet	10.6	4.5?	4.6?	4.4?
vp	Br. attach. projection	13.1	8.9	5.5?	9.4
q	Ant. Post depth from facet to facet	8.9	4.1	3.9	3.8
h	ant. post. depth bdy	2.3	no bridge	1.5	none
i	ant. post. depth bet. post. facet projection to ant. facet	7.3	3.7	3.2	3.8?
j	ant. depth lat. strut immed. above post. facet	5.6	2.5	2.6	2.9
k	lat. br. through bone and post. facet (conc. side)	5.3	2.5	2.5	3.2
Ratio g to c		50.670	45.120	47.690	35.220
" a to c		88	85.6	91.5	86.7
" e to d		62	50.6	56.6	41.5
" b to a		93.6	82.0	93.5	78.3
" e to c		60.1	44.5	56.1	40.6

Atlases compared

(56) *Puffinus griseus* has cartilage spanning the orifice for the odontoid process. Same is true of *Luluanus glac.* (27)

(1377) *Aukinga* has bony bridge in this place
 18173 } *Moris* " " " " "
 1352 } *Sula* " " " " "

Pelecanus both occident. (629) & *erythrorhynchus* (1770) are open in this area

Accompanying bridge in *Aukinga*, *Sula* & *Moris* is deep though partly for odont.

Fossil atlas ①, posteriorly the facet for articulation with the axis is, V-shaped, ^{the tip comes to level of ant. art.} with very convex surface at the lower end. The facet is markedly separated from the projection, that would underlie the ant. part of the ^{center} of the axis. Bone above facet does not recede forwards but continues upwards, not much laterally. Area for odontoid process is narrow, deep ant. post. by

② Area for odontoid process is narrow, deep ant. post. by

③ Hole " " " " " is bridged with bone

④ Projection to underlie axis is broad where it attaches but broken so that its extent is unknown

Ant. ⑤ art. with skull is deeply concave, broader dorsally than ventrally. Pear-shaped. High rel. to width

Main distinctions bet. *Procell.* & *Pelecanit.*

① Post. facet never U or V shaped in *Procell.*; frequently is in *Pel.* (no not in *Phalacrocor.*)

② Labial struts flare outwards before facets more in *Pro.* straighten up in *Pelecanit.*

③ Bony bridge in 2 families (*Pelecanit.*)
 Cartilage " " " " (*Procell.*)

④ Deep ^{ventral} space for odontoid more in *Pelecanit.*

Atlas in Pelecaniformes

Pelecanus occidentalis (629)

① ^{Partly} Very large art. slightly convex. Bone above recedes slightly antly & very slight outwards. Ant. about to edge of ant. art. No ~~mark~~ undercut to projection below

② Area for odontoid process pneumatic, faint deep

③ No bridge

④ Projection narrow (may be inaccurate - see 1770)

⑤ Antly art. with skull not very deep. Upper end slightly wider than lower & projects anteriorly

P. erythrorhynchos (1770)

① same as 629 but more undercut below

② same as 629

③ no bridge

④ Projection very broad - full span of facet

⑤ essentially same

Fregata 243 ~~5249~~

① Ant. absent as in *Fulmarus*

② Broad & not deep (similar to *Fulmarus*)

③ No bridge

④ Projection about (not quite) same broad th as facet

⑤ Similar to *Fulmarus* & Puffins & *Diomedea*

Colinus 1377

① ^{Partly} Large V-shaped art. but ant. art. is higher. Bone on sides recedes slightly antly & ^{outwards} outwards. Very slight undercut below

② Area for odontoid broad & deep

③ Bridge bony, thin ~~subchondral~~ for odont. tip

④ Projection narrow

⑤ Ant. with skull quite jointed below, broader dorsally & bony bridge is more dorsal than the sides (convex dorsal border). Bone below narrow behind the art.

In its solid cross section and longitudinal groove, ^{this} ~~the~~ bone bears some resemblance to an avian ceratobranchial. It is not, however, identical in contour with any ceratobranchial available for comparison, and is considerably longer. In the procellariiform and pelecaniform birds examined, the zygoma and the ceratobranchial span approximately the same distance on the skull, one at the side, the other below. As seen in the type specimen of Osteodontornis orri, the posterior part of the skull is relatively short and the zygoma, though very broad, measures only 83 mm. in length (Howard, 1957, p. 9); this length is equalled, or even exceeded, in some specimens of Pelecanus occidentalis and Diomedea exulans. If the zygoma length can be taken as a guide to the length of the ceratobranchial in O. orri, the element here under consideration is much too long to ^{represent this element in} ~~belong to~~ this fossil species. There is, of course, the epibranchial to be considered; this element ^{might} ~~may~~ attain unpredictable length depending on the use the bird made of the tongue. The ^{fossil} ~~bone~~, however, does not resemble any epibranchial available for examination. Another possible element that ^{might be} ~~it may~~ represent is a sternal rib. Sternal rib no. 3 in sulids bears a longitudinal groove for about half its length. ~~xxxxx~~ The sternal ribs examined for several orders of birds, however, ~~all~~ are hollow, not solid in cross section as in the fossil, and all are relatively broader. Although this element was found with the specimen of Osteodontornis, it is possible, of course, that it does not belong to this bird. The deposit is rich in fish, and this one element may be an isolated fishbone.

28 March 1956
Long Beach, California

Dear Dr. Howard:

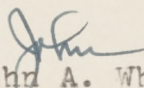
The fragment of "tooth" from the Miocene bird became shattered when I tried to improve the quality of the section. However, while grinding the specimen, I studied it repeatedly and this is what I observed:

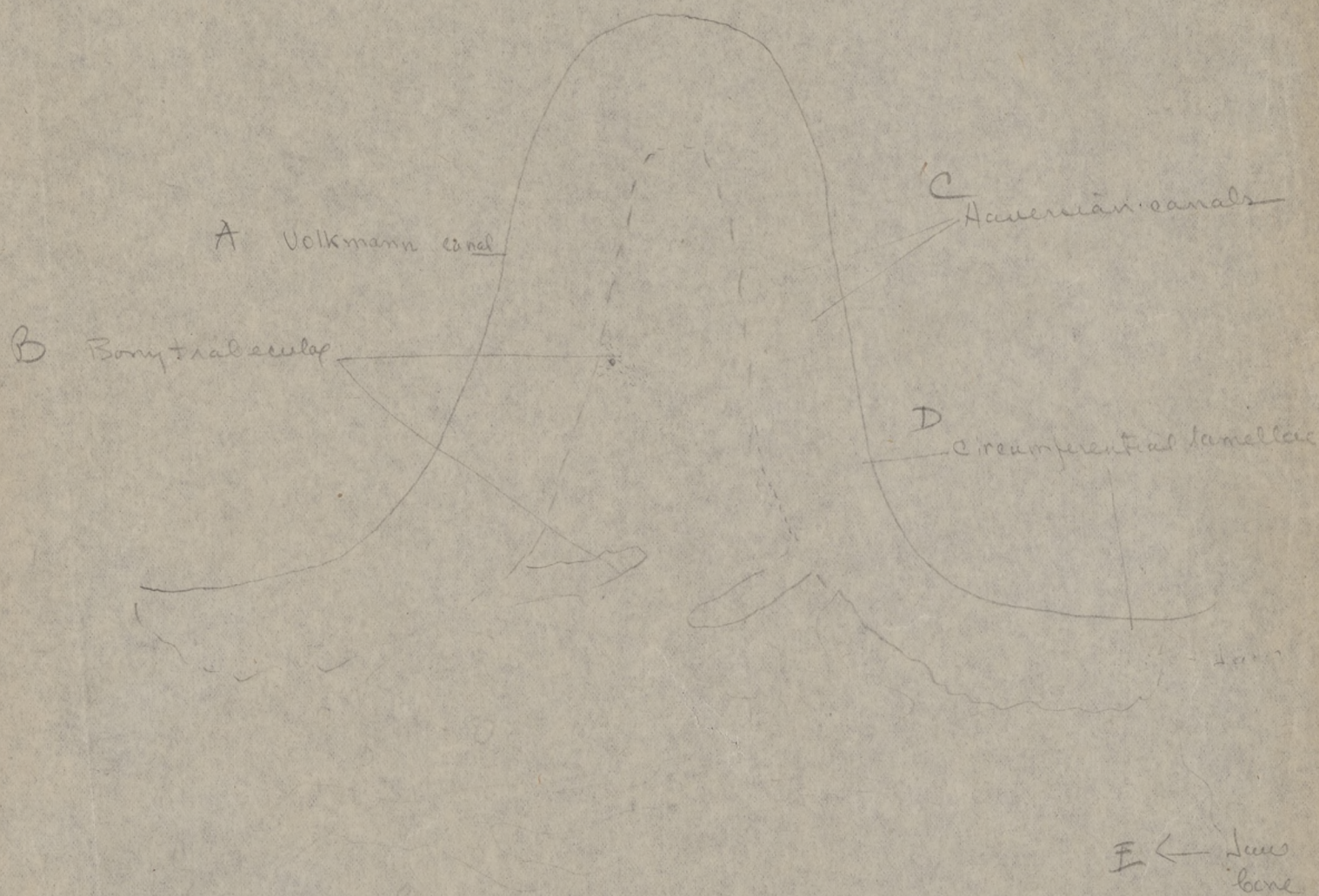
1. The inner portion of the "tooth" is composed of bone as indicated by several Haversian systems, part of which may be seen in the fragments:



2. The outer portion which seemed to be harder, is filled with lacunae and no Haversian canals — a structure characteristic of cementum ~~and~~ perichondral bone.
3. No evidence of enamel or dentine was seen.
4. Other foramina were noted which seemed to connect the inside of the tooth with the outside.

I am sorry the specimen is ruined. If you can provide me with another fragment I will be glad to grind it for you and I can promise better results.


John A. White



By J. A. White

Reconstruction of a thin section through
a bone-tooth and associated jaw bone
of Osteodontornis



Tooth
enlarged & sectioned